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MANUAL OF SEPTIC-TANK PRACTICE

National Center for Urban and Industrial Health
Cincinnati, Ohio

1967

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U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Public Health Service

PB 216 240

Manual of SEPTIC-TANK PRACTICE

Developed in Cooperation with the Joint Committee on Rural Sanitation

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

Bureau of Disease Prevention and Environmental Control
National Center for Urban and Industrial Health
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Foreword

In the preparation of this manual, the Public Health Service was fortunate in having the advisory assistance of the Joint Committee on Rural Sanitation. This committee is composed of specialists from governmental and other agencies in the field of rural sanitation. Their comments and suggestions based on the long experience of the members were invaluable in the preparation of the manual. The following individuals and organizations constitute the current Committee membership:

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Preface

Population movement within the United States continues to be from rural to metropolitan areas. Because of the difficulty of providing adequate sewerage systems for this new growth, individual septic tank – soil absorption systems continue to be an important method of sewage disposal where they are acceptable. Accurate figures are not available, but it is estimated that at present 49 million persons are served by 15 million individual sewage-disposal systems in the United States. Of even more importance, roughly one-fourth of the new homes are being constructed with these systems.

In 1946, the Public Health Service, in cooperation with Federal agencies concerned with housing, undertook a 5-year study on septic tank – soil absorption systems, seeking to develop a factual basis on which they could be designed, installed and maintained. These studies are described in detail in three technical reports: *Studies on Household Sewage Disposal Systems*, Parts I, II, and III.

Subsequent studies on septic tanks and soil absorption systems have been conducted by the Public Health Service, Federal Housing Administration, Universities and other organizations.

This manual is a revision of PHS Publication No. 526, *Manual of Septic Tank Practice*, issued in 1957, and reprinted in 1963 with Addendums on "Serial Distribution Systems" and "Seepage Beds." The updating reflects changing trends in the problems of individual sewage disposal systems and includes new information in this field.

The decision on the suitability of septic-tank installations must be based on many factors outside of those covered in the manual. It is emphasized, however, that connection to an adequate public sewerage system is the most satisfactory method of disposing of sewage. Every effort should be made, therefore, to secure public-sewer extensions. Where connection to a public sewer is not feasible, and when a considerable number of residences are to be served, consideration should be given next to the construction of a community sewerage system and treatment plant. Specific information on this matter should be obtained from the local authority having jurisdiction.

Individuals proposing to construct individual sewage-disposal systems should consult the officials having jurisdiction over such installations in their area. A number of States and localities have developed requirements which have been incorporated in their official regulations, in many cases soundly based on conditions peculiar to those areas and

adequately representing good practice there. The recommendations contained in this manual should be considered as supplemental to such local requirements. Builders, homeowners, and others interested in septic-tank systems should seek advance guidance from the local authorities prior to land acquisition, in order to have the benefits of their experience as well as their approval of plans and construction.

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Part I

Septic Tank - Soil Absorption Systems for Private Residences

INTRODUCTION

A major factor influencing the health of individuals where public sewers are not available is the proper disposal of human excreta. Many diseases, such as dysentery, infectious hepatitis, typhoid and paratyphoid, and various types of diarrhea are transmitted from one person to another through the fecal contamination of food and water, largely due to the improper disposal of human wastes. For this reason, every effort should be made to prevent such hazards and to dispose of all human waste so that no opportunity will exist for contamination of water or food.

Safe disposal of all human and domestic wastes is necessary to protect the health of the individual family and the community and to prevent the occurrence of nuisances. To accomplish satisfactory results, such wastes must be disposed of so that:

1. They will not contaminate any drinking water supply.
2. They will not give rise to a public health hazard by being accessible to insects, rodents, or other possible carriers which may come into contact with food or drinking water.
3. They will not give rise to a public health hazard by being accessible to children.
4. They will not violate laws or regulations governing water pollution or sewage disposal.
5. They will not pollute or contaminate the waters of any bathing beach, shellfish breeding ground, or stream used for public or domestic water supply purposes, or for recreational purposes.
6. They will not give rise to a nuisance due to odor or unsightly appearance.

These criteria can best be met by the discharge of domestic sewage to an adequate public or community sewerage system. Where the instal-

lation of an individual household sewage disposal system is necessary, the basic principles outlined in this manual on design, construction, installation, and maintenance should be followed. When these criteria are met, and where soil and site conditions are favorable, the septic tank system can be expected to give satisfactory service. Experience has shown that adequate supervision, inspection and maintenance of all features of the system are required to insure compliance in this respect. Underground portions of the system should be inspected before being covered, so necessary corrections can be made.

DEFINITIONS

Absorption Trench—A trench not over 36″ in width with a minimum of 12″ of clean, coarse aggregate and a distribution pipe, and covered with a minimum of 12″ of earth cover.

Standard Absorption Trench—A trench 12″ to 36″ in width containing 12″ of clean, coarse aggregate and a distribution pipe, covered with a minimum of 12″ of earth cover.

Building Drain—That part of the lowest piping of a drainage system which receives the discharge from soil, waste, and other drainage pipes inside the walls of the building and conveys it to the building sewer beginning three feet outside the building wall.

Building Sewer—That part of a drainage system which extends from the end of the building drain and conveys its discharge to a public sewer, private sewer, individual sewage disposal system or other point of disposal.

Cesspool—A lined and covered excavation in the ground which receives the discharge of domestic sewage or other organic wastes from a drainage system, so designed as to retain the organic matter and solids, but permitting the liquids to seep through the bottom and sides.

Drainage Fixture Unit Value—A common measure of the probable discharge into a drainage system by various types of plumbing fixtures. This value for a particular fixture depends on its volume rate of drainage discharge, on the time duration of a single drainage operation, and on the average time between successive operations.

Effective Size—That size of sand of which 10% by weight is smaller.

Individual Sewage Disposal System—A single system of sewage treatment tanks and disposal facilities serving only a single lot.

Sand Filter Trenches—A system of trenches, consisting of perforated pipe or drain tile surrounded by clean, coarse aggregate containing an intermediate layer of sand as filtering material and provided with an underdrain for carrying off the filtered sewage.

Scum—A mass of sewage matter which floats on the surface of sewage.

Scum Clear Space—Distance between the bottom of the scum mat and the bottom of the outlet device.

Seepage Bed—A trench or bed exceeding 36″ in width containing 12″

a minimum of clean, coarse aggregate and a system of distribution piping through which treated sewage may seep into the surrounding soil.

Seepage Pit—A covered pit with lining designed to permit treated sewage to seep into the surrounding soil.

Septic Tank—A water-tight, covered receptacle designed and constructed to receive the discharge of sewage from a building sewer, separate solids from the liquid, digest organic matter and store digested solids through a period of detention, and allow the clarified liquids to discharge for final disposal.

Serial Distribution—An arrangement of absorption trenches, seepage pits, or seepage beds so that each is forced to pond to utilize the total effective absorption area before liquid flows into the succeeding component.

Sewage—Any liquid waste containing animal or vegetable matter in suspension or solution, and may include liquids containing chemicals in solution.

Sludge—The accumulated settled solids deposited from sewage and containing more or less water to form a semi-liquid mass.

Sludge Clear Space—The distance between the top of the sludge and the bottom of the outlet device.

Soil Absorption Field—A system of absorption trenches.

Soil Absorption System—Any system that utilizes the soil for subsequent absorption of the treated sewage; such as an absorption trench, seepage bed, or a seepage pit.

Subsurface Sand Filters—A wide bed, consisting of a number of lines of perforated pipe or drain tile surrounded by clean coarse aggregate, containing an intermediate layer of sand as filtering material, and provided with a system of underdrains for carrying off the filtered sewage.

Subsurface Sewage Disposal System—A system for the treatment and disposal of domestic sewage by means of a septic tank and a soil absorption system.

Uniformity Coefficient—A coefficient obtained by dividing that size of sand of which 60% by weight is smaller, by that size of sand of which 10% by weight is smaller.

SUITABILITY OF SOIL

The first step in the design of subsurface sewage disposal systems is to determine whether the soil is suitable for the absorption of septic tank effluent and, if so, how much area is required. The soil must have an acceptable percolation rate, without interference from ground water or impervious strata below the level of the absorption system. In general, two conditions must be met:

(1) The percolation time should be within the range of those specified in Table 1, p. 8.

(2) The maximum seasonal elevation of the ground water table should be at least 4-feet below the bottom of the trench or seepage pit. Rock formulations or other impervious strata should be at a depth greater than 4-feet below the bottom of trench or seepage pit.

Unless these conditions can be satisfied, the site is unsuitable for a conventional subsurface sewage disposal system.

PERCOLATION TESTS

Subsurface explorations are necessary to determine subsurface formations in a given area. An auger with an extension handle, as shown in Figure 1 (p. 5), is often used for making the investigation. In some cases, an examination of road cuts, stream embankments, or building excavations will give useful information. Wells and well drillers' logs can also be used to obtain information on ground water and subsurface conditions. In some areas, subsoil strata vary widely in short distances, and borings must be made at the site of the system. If the subsoil appears suitable, as judged by other characteristics described in Appendix A, percolation tests should be made at points and elevations selected as typical of the area in which the disposal field will be located.

The percolation tests help to determine the acceptability of the site and establish the design size of the subsurface disposal system. The length of time required for percolation tests will vary in different types of soil. The safest method is to make tests in holes which have been kept filled with water for at least 4 hours, preferably overnight. This is particularly desirable if the tests are to be made by an inexperienced person, and in some soils it is necessary even if the individual has had considerable experience (as in soils which swell upon wetting). Percolation rates should be figured on the basis of the test data obtained after the soil has had opportunity to become wetted or saturated and has had opportunity to swell for at least 24 hours. Enough tests should be made in separate holes to assure that the results are valid.

The percolation test developed at the Robert A. Taft Sanitary Engineering Center incorporates these principles. Its use is particularly recommended when knowledge of soil types and soil structure is limited. When previous experience and information on soil characteristics are available, some persons prefer other percolation test procedures, such as those developed by Kiker and by Ludwig which are cited in Appendix A.

Procedure for Percolation Tests Developed at Robert A. Taft Sanitary Engineering Center

1. *Number and location of tests.*—Six or more tests shall be made in separate test holes spaced uniformly over the proposed absorption field site.

2. *Type of test hole.*—Dig or bore a hole, with horizontal dimensions of from 4 to 12 inches and vertical sides to the depth of the proposed absorption trench. In order to save time, labor, and volume of water

Figure 1.—Auger and extension handle for making test borings.

required per test, the holes can be bored with a 4 inch auger. (See Fig. 2, page 7.)

3. *Preparation of test hole.*—Carefully scratch the bottom and sides of the hole with a knife blade or sharp-pointed instrument, in order to remove any smeared soil surfaces and to provide a natural soil interface into which water may percolate. Remove all loose material from the hole. Add 2 inches of coarse sand or fine gravel to protect the bottom from scouring and sediment.

4. *Saturation and swelling of the soil.*—It is important to distinguish between saturation and swelling. Saturation means that the void spaces between soil particles are full of water. This can be accomplished in a short period of time. Swelling is caused by intrusion of water into the individual soil particle. This is a slow process, especially in clay-type soil, and is the reason for requiring a prolonged soaking period.

In the conduct of the test, carefully fill the hole with clear water to a minimum depth of 12 inches over the gravel. In most soils, it is necessary to refill the hole by supplying a surplus reservoir of water, possibly by means of an automatic syphon, to keep water in the hole for at least 4 hours and preferably overnight. Determine the percolation rate 24 hours after water is first added to the hole. This procedure is to insure that the soil is given ample opportunity to swell and to approach the condition it will be in during the wettest season of the year. Thus, the test will give comparable results in the same soil, whether made in a dry or in a wet season. In sandy soils containing little or no clay, the swelling procedure is not essential, and the test may be made as described under item 5C, after the water from one filling of the hole has completely seeped away.

5. *Percolation-rate measurement.*—With the exception of sandy soils, percolation-rate measurements shall be made on the day following the procedure described under item 4, above.

A. If water remains in the test hole after the overnight swelling period, adjust the depth to approximately 6 inches over the gravel. From a fixed reference point, measure the drop in water level over a 30 minute period. This drop is used to calculate the percolation rate.

B. If no water remains in the hole after the overnight swelling period, add clear water to bring the depth of water in the hole to approximately 6 inches over the gravel. From a fixed reference point, measure the drop in water level at approximately 30 minute intervals for 4 hours, refilling 6 inches over the gravel as necessary. The drop that occurs during the final 30 minute period is used to calculate the percolation rate. The drops during prior periods provide information for possible modification of the procedure to suit local circumstances.

C. In sandy soils (or other soils in which the first 6 inches of water seeps away in less than 30 minutes, after the overnight swelling period), the time interval between measurements shall be taken as 10 minutes and the test run for one hour. The drop that occurs during the final 10 minutes is used to calculate the percolation rate.

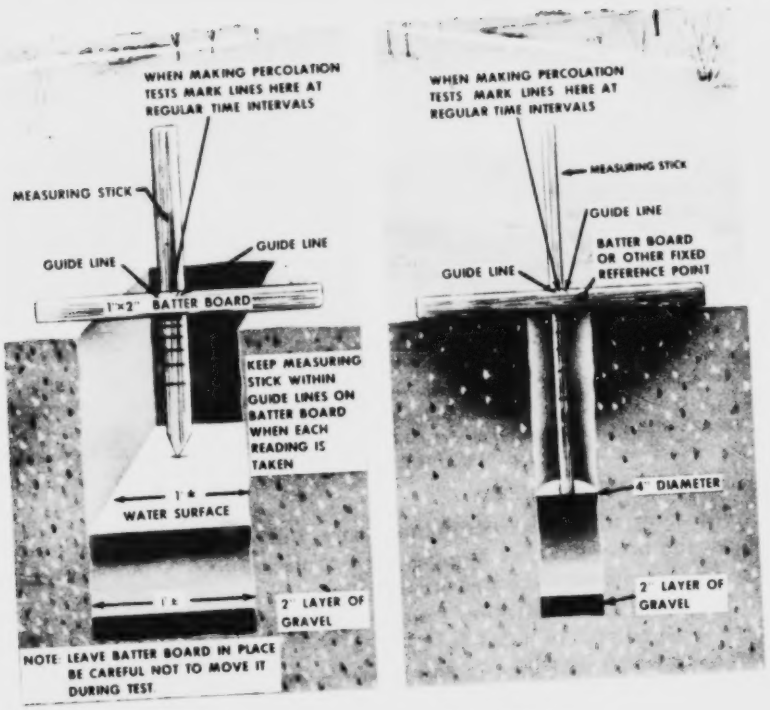
WHEN MAKING PERCOLATION TESTS MARK LINES HERE AT REGULAR TIME INTERVALS
MEASURING STICK
GUIDE LINE
GUIDE LINE
1"×2" BATTER BOARD
KEEP MEASURING STICK WITHIN GUIDE LINES ON BATTER BOARD WHEN EACH READING IS TAKEN
1"
WATER SURFACE
1"
2" LAYER OF GRAVEL
NOTE: LEAVE BATTER BOARD IN PLACE BE CAREFUL NOT TO MOVE IT DURING TEST
WHEN MAKING PERCOLATION TESTS MARK LINES HERE AT REGULAR TIME INTERVALS
MEASURING STICK
GUIDE LINE
BATTER BOARD OR OTHER FIXED REFERENCE POINT
GUIDE LINE
4" DIAMETER
2" LAYER OF GRAVEL

Figure 2.—Methods of making percolation tests.

Reproduced from best available copy.

Table 1.—*Absorption-area requirements for individual residences* (a)

[Provides for garbage grinder and automatic clothes washing machines]

Percolation rate (time required for water to fall one inch, in minutes)	Required absorption area, in sq. ft. per bedroom (b), standard trench (c), seepage beds (c), and seepage pits (d)	Percolation rate (time required for water to fall one inch, in minutes)	Required absorption area in sq. ft. per bedroom (b), standard trench (c), and seepage beds (c), and seepage pits (d)
1 or less	70	10	165
2	85	15	190
3	100	30 (e)	250
4	115	45 (e)	300
5	125	60 (e), (f)	330

(a) It is desirable to provide sufficient land area for entire new absorption system if needed in future.[1]

(b) In every case sufficient land area should be provided for the number of bedrooms (minimum of 2) that can be reasonably anticipated, including the unfinished space available for conversion as additional bedrooms.

(c) Absorption area is figured as trench-bottom area and includes a statistical allowance for vertical side wall area.

(d) Absorption area for seepage pits is figured as effective side wall area beneath the inlet.

(e) Unsuitable for seepage pits if over thirty.

(f) Unsuitable for absorption systems if over sixty.

[1] Section 5.1(b) (2) (A) Page 20 of *Recommended State Legislation and Regulations: Urban Water Supply and Sewerage Systems Act and Regulations, Water Well Construction and Pump Installation Act and Regulations, Individual Sewerage Disposal Systems Act and Regulations.* U.S.D.H.E.W. Public Health Service, July 1965.

SOIL ABSORPTION SYSTEM

For areas where the percolation rates and soil characteristics are good, the next step after making the percolation tests is to determine the required absorption area from Table 1 or Figure 3 (page 9), and to select the soil absorption system that will be satisfactory for the area in question. As noted in Table 1, soil in which the percolation rate is slower than 1 inch in 30 minutes is unsuitable for seepage pits, and that slower than 1 inch in 60 minutes is unsuitable for any type of soil absorption system.

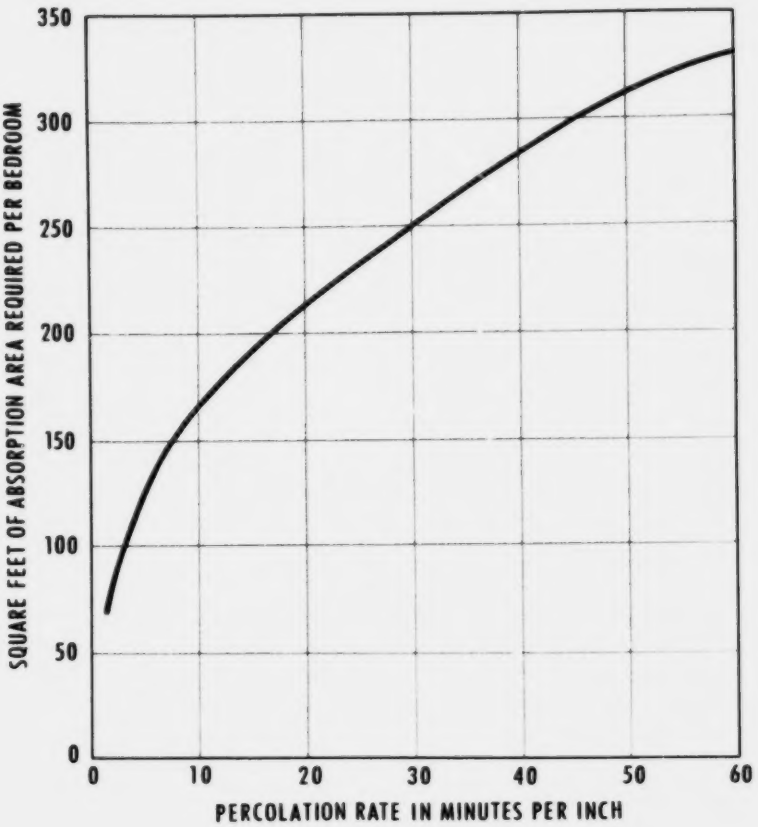

Figure 3.—Absorption area requirements for private residences.

When a soil absorption system is determined to be useable, three types of design may be considered: Absorption trenches, seepage beds, and seepage pits. A modification of the standard absorption trench is discussed on page 20 giving credit for more than the standard 12 inches of gravel depth in the trench.

The selection of the absorption system will be dependent to some extent on the location of the system in the area under consideration. A safe distance should be maintained between the site and any source of water supply. Since the distance that pollution will travel underground depends upon numerous factors, including the characteristics of the subsoil formations and the quantity of sewage discharged, no specified distance would be absolutely safe in all localities. Ordinarily, of course, the greater the distance, the greater will be the safety provided. In general, location of components of sewage disposal systems should be as shown in the following table.

Table 2.—*Minimum distance between components of sewage disposal system*

Component of System	Horizontal Distance (feet)				
	Well or suction line	Water supply line (pressure)	Stream	Dwelling	Property line
Building sewer	50	10 (a)	50	....	....
Septic tank	50	10	50	5	10
Disposal field and Seepage Bed	100	25	50	20	5
Seepage Pit	100	50	50	20	10
Cesspool (b)	150	50	50	20	15

(a) Where the water supply line must cross the sewer line, the bottom of the water service within 10 feet of the point of crossing, shall be at least 12 inches above the top of the sewer line. The sewer line shall be of cast iron with leaded or mechanical joints at least 10 feet on either side of the crossing.

(b) Not recommended as a substitute for a septic tank. To be used only when found necessary and approved by the health authority.

Seepage pits should not be used in areas where domestic water supplies are obtained from shallow wells, or where there are limestone formations and sinkholes with connection to underground channels through which pollution may travel to water sources.

Details pertaining to local water wells, such as depth, type of construction, vertical zone of influence, etc., together with data on the geological formations and porosity of subsoil strata, should be considered in determining the safe allowable distance between wells and subsurface disposal systems.

Absorption Trenches

A soil absorption field consists of a field of 12 inch lengths of 4 inch agricultural drain tile, 2 to 3 foot lengths of vitrified clay sewer pipe, or perforated, nonmetallic pipe. In areas having unusual soil or water characteristics, local experience should be reviewed before selecting piping materials. The individual laterals preferably should not be over 100 feet long, and the trench bottom and tile distribution lines should be level. Use of more and shorter laterals is preferred because if something should happen to disturb one line, most of the field will still be serviceable. From a theoretical moisture flow viewpoint, a spacing of twice the depth of gravel would prevent taxing the percolative capacity of the adjacent soil.

Many different designs may be used in laying out subsurface disposal fields. The choice may depend on the size and shape of the available

disposal area, the capacity required, and the topography of the disposal area.

Typical layouts of absorption trenches are shown in Figures 4, 6, pages 11, and 17.

To provide the minimum required gravel depth and earth cover, the depth of the absorption trenches should be at least 24 inches. Additional depth may be needed for contour adjustment, extra aggregate under the tile, or other design purposes. The maintenance of a 4 feet separation between the bottom of the trench and the water table is required to minimize ground water contamination. In considering the depth of the absorption field trenches, the possibility of tile lines freezing during prolonged cold period is raised. Freezing rarely occurs in a carefully constructed system kept in continuous operation. It is important during construction to assure that the tile lines are surrounded by gravel. Pipes under driveways or other surfaces which are usually cleared of snow should be insulated.

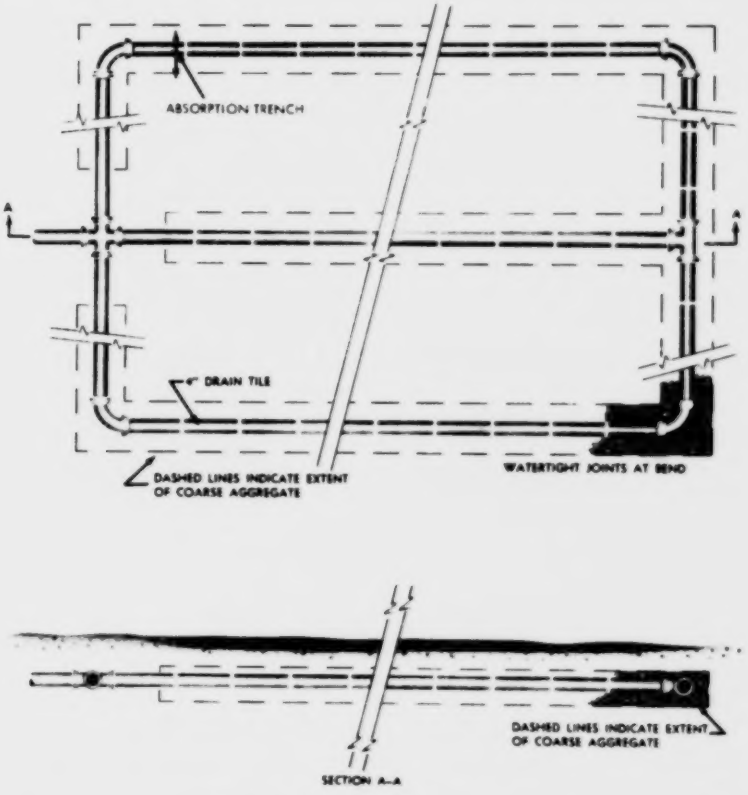
ABSORPTION TRENCH
4" DRAIN TILE
DASHED LINES INDICATE EXTENT OF COARSE AGGREGATE
WATERTIGHT JOINTS AT BEND
DASHED LINES INDICATE EXTENT OF COARSE AGGREGATE
SECTION A-A

Figure 4.—Typical layout of absorption trench.

The required absorption area is predicated on the results of the soil percolation test, and may be obtained from column 2 or 4 of Table 1 (page 8), or Figure 3 (page 9). Note especially that the area requirements are per bedroom. The area of the lot on which the house is to be built should be large enough to allow room for an additional system if the first one fails. Thus for a 3 bedroom house on a lot where the minimum percolation rate was 1 inch in 15 minutes, the necessary absorption area will be 3 bedrooms × 190 sq. ft. per bedroom, or 570 sq. ft. For trenches 2 feet wide with 6 inches of gravel below the drain pipe, the required total length of trench would be 570 ÷ 2, or 285 feet. If this were divided into 5 portions (i.e., 5 laterals), the length of each line would be 285 ÷ 5, or 57 feet. The spacing of trenches is generally governed by practical construction considerations dependent on the type of equipment, safety, etc. For serial distribution on sloping ground, trenches should be separated by 6 feet to prevent short circuiting. Table 2, page 10, gives the various distances the system has to be kept away from wells, dwellings, etc.

In the example cited, trenches are 2 feet wide × 5 trenches = 10 feet plus 6 feet between trenches × 4 spaces = 24 feet. The total width of 34 feet × 57 feet in length = 1,938 square feet, plus additional land required to keep the field away from wells, property lines, etc.

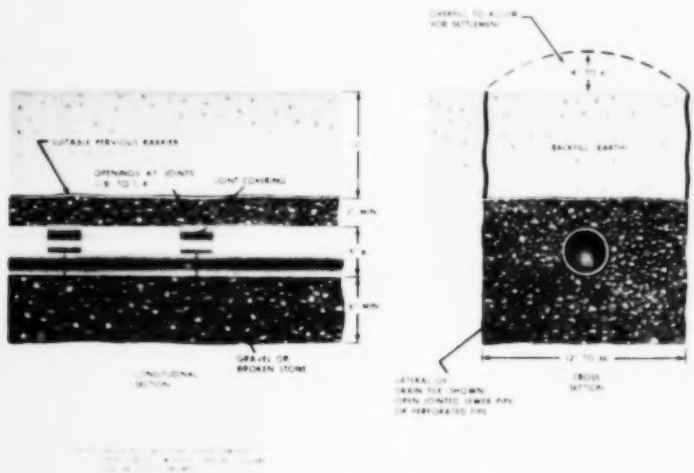

Figure 5.—Absorption trench and lateral.

Construction Considerations.—Careful construction is important in obtaining a satisfactory soil absorption system. Attention should be given to the protection of the natural absorption properties of the soil. Care must be taken to prevent sealing of the surface on the bottom

and sides of the trench. Trenches should not be excavated when the soil is wet enough to smear or compact easily. Soil moisture is right for safe working only when a handful will mold with considerable pressure. Open trenches should be protected from surface runoff to prevent the entrance of silt and debris. If it is necessary to walk in the trench, a temporary board laid on the bottom will reduce the damage. Some smearing and damage is bound to occur. All smeared or compacted surfaces should be raked to a depth of 1 inch, and loose material removed, before the gravel is placed in the trench.

The pipe, laid in a trench of sufficient width and depth, should be surrounded by clean, graded gravel or rock, broken hard burned clay brick, or similar aggregate. The material may range in size from ½ inch to 2½ inches. Cinders, broken shell, and similar material are not recommended, because they are usually too fine and may lead to premature clogging. The material should extend from at least 2 inches above the top of the pipe to at least 6 inches below the bottom of the pipe. If tile is used, the upper half of the joint openings should be covered, as shown in Figure 5, page 12. The top of the stone should be covered, with untreated building paper, a 2 inch layer of hay or straw, or similar pervious material to prevent the stone from becoming clogged by the earth backfill. An impervious covering should not be used, as this interferes with evaportranspiration at the surface (see Appendix A, page 74). Although generally not figured in the calculations, evapotranspiration is often an important factor in the operation of horizontal absorption systems.

Drain tile connectors, collars, clips, or other spacers with covers for the upper half of the joints are of value in obtaining uniform spacing, proper alignment, and protection of tile joints, but use of such aides is optional. They have been made of galvanized iron, copper, and plastic.

It has been found that root problems may be prevented best by using a liberal amount of gravel or stone around the tile. Clogging due to roots has occurred mostly in lines with insufficient gravel under the tile. Furthermore, roots seek the location where moisture conditions are most favorable for growth and, in the small percentage of cases where they become troublesome in well designed installations, there is usually some explanation involving the moisture conditions. At a residence which is used only during the summer, for example, roots are most likely to penetrate when the house is uninhabited, or when moisture immediately below or around the gravel becomes less plentiful than during the period when the system is in use. In general, trenches constructed with 10 feet of large trees or dense shrubbery should have at least 12 inches of gravel or crushed stone beneath the tile.

"If trees are near the sewage disposal system, difficulty with roots entering poorly joined sewer lines can be anticipated. Lead-caulked cast iron pipe, a sulfur base or bituminous pipe joint compound, me-

chanical clay pipe joints, copper rings over joints and lump copper sulfate in pipe trenches have been found effective in resisting the entrance of roots into pipe joints. Roots will penetrate into the gravel in tile field trenches rather than into the pipe. About 2 or 3 pounds of copper sulfate crystals flushed down the toilet bowl once a year will destroy roots the solution comes in contact with, but will not prevent new roots from entering. The application of the chemical should be done at a time, such as late in the evening when the maximum contact time can be obtained before dilution. Copper sulfate will corrode chrome, iron and brass, hence it should not be allowed to come into contact with these metals. Cast iron is not affected to any appreciable extent. Some time must elapse before the roots are killed and broken off. Copper sulfate in the recommended dosage will not interfere with operation of the septic tank." [1]

The top of a new absorption trench should be hand tamped and should be overfilled with about 4 to 6 inches of earth. Unless this is done, the top of the trench may settle to a point lower than the surface of the adjacent ground. This will cause the collection of storm water in the trench, which can lead to premature saturation of the absorption field and possibly to complete washout of the trench. Machine tamping or hydraulic backfilling of the trench should be prohibited.

Where sloping ground is used for the disposal area, it is usually necessary to construct a small temporary dike or surface water diversion ditch above the field, to prevent the disposal area from being washed out by rain. The dike should be maintained or the ditch kept free of obstructions until the field becomes well covered with vegetation.

A heavy vehicle would readily crush the tile in a shallow absorption field. For this reason, heavy machinery should be excluded from the disposal area unless special provision is made to support the weight. All machine grading should be completed before the field is laid.

The use of the field area must be restricted to activities which will not contribute to the compaction of the soil with the consequent reduction in soil aeration.

Seepage Beds

Common design practice for soil absorption systems for private residences provides for trench widths up to 36 inches. Variations of design utilizing increased width are being used in many areas. Absorption systems having trenches wider than 3 feet are referred to as seepage beds. The design of trenches is based on an empirical relationship between the percolation test and the bottom area of the trenches. The use of seepage beds has been limited by the lack of experience with their performance and the absence of design criteria comparable to that for trenches.

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[1] Joseph A. Salvato, "Environmental Sanitation," page 214.

Studies sponsored by the Federal Housing Administration have demonstrated that the seepage bed is a satisfactory device for disposing of effluent in soils that are acceptable for soil absorption systems. The studies have further demonstrated that the empirical relationship between the percolation test and bottom area required for trenches is applicable for seepage beds.

There are three main elements of a seepage bed: absorption surface, rockfill or packing material, and the distribution system. The design of the seepage bed should be such that the total intended absorption area is preserved, sufficient packing material is provided in the proper place to allow for further treatment and storage of excess liquid, and a means for distributing the effluent is protected against siltation of earth backfill and mechanical damage. Construction details for a conventional seepage bed are outlined in the following material in such a way that these principal design elements are incorporated. Tabulation of construction details for the conventional seepage bed is not intended to preclude other designs which may provide the essential features in a more economical or otherwise desirable manner. Specifically, there may be equally acceptable or even superior methods developed for distributing the liquid than by tile or perforated pipe covered with gravel.

The use of seepage beds results in the following advantages:

1. A wide bed makes more efficient use of land available for absorption systems than a series of long narrow trenches with wasted land between the trenches.

2. Efficient use may be made of a variety of modern earth moving equipment employed at housing projects for other purposes such as basement excavation and landscaping, resulting in savings on the cost of the system.

Construction Considerations.—When seepage beds are used, the following design and construction procedures providing for rockfill or packing material, an adequate distribution system, and protection of the absorption area, should be observed:

1. The amount of bottom absorption area required shall be the same as shown in Table 1, page 8.

2. Percolation tests should be conducted in accordance with pages 4–8.

3. The bed should have a minimum depth of 24 inches below natural ground level to provide a minimum earth backfill cover of 12 inches.

4. The bed should have a minimum depth of 12 inches of rockfill or packing material extending at least 2 inches above and 6 inches below the distribution pipe.

5. The bottom of the bed and distribution tile or perforated pipe should be level.

6. Lines for distributing effluent shall be spaced not greater than 6 feet apart and not greater than 3 feet from the bed sidewall.

7. When more than one bed is used: (a) there should be a minimum of 6 feet of undisturbed earth between adjacent beds; and (b) the beds should be connected in series in accordance with the section concerning serial distribution, below.

8. Applicable construction considerations for standard trenches on pages 10 through 14 should also be followed.

Distribution Boxes

The Final Report to the Federal Housing Administration on the study to: Determine if Distribution Boxes can be Eliminated Without Inducing Increased Failure of Disposal Fields by the Public Health Service reached the following conclusions:

1. Distribution boxes can be eliminated from septic tank-soil absorption systems in favor of some other method of distribution without inducing increased failure of disposal fields. In fact, evidence indicates that distribution boxes as presently used may be harmful to the system.

2. Data indicates that on level ground, equal distribution is not necessary if the system is designed so that an overloaded trench can drain back to the other trenches before failure occurs.

3. On sloping ground a method of distribution is needed to prevent excessive build-up of head and failure of any one trench before the capacity of the entire system is utilized. It is doubtful that distribution boxes as presently used give equal distribution. Rather, they probably act as diversion devices sending most of the liquid to part of the system.

For the above reasons it is recommended that distribution boxes not be used for individual sewage disposal systems.

Serial Distribution

Serial distribution is achieved by arranging individual trenches of the absorption system so that each trench is forced to pond to the full depth of the gravel fill before liquid flows into the succeeding trench.

Serial distribution has the following advantages:

1. Serial distribution minimizes the importance of variable absorption rates by forcing each trench to absorb effluent until its ultimate capacity is utilized. The variability of soils even in the small area of an individual absorption field raises doubt of the desirability of uniform distribution. Any one or a combination of factors may lead to nonuniform absorptive capacity of the several trenches in a system. Varying physical and chemical characteristics of soil, construction damage such as soil interface smearing or excessive compaction, poor surface drainage, and variation in depth of trenches are some of the factors involved.

2. Serial distribution causes successive trenches in the absorption system to be used to full capacity. Serial distribution has a distinct advantage on sloping terrain. With imperfect division of flow in a parallel system, one trench could become overloaded, resulting in a surcharged condition. If the slope of the ground and elevation of the distribution box were such that a surcharged trench continued to re-

ceive more effluent than it could absorb, local failure would occur before the full capacity of the system was utilized.

3. The cost of the distribution box is eliminated in serial distribution. Also, long runs of closed pipe connecting the box to each trench are unnecessary.

Fields in Flat Areas.—Where the slope of the ground surface does not exceed six inches in any direction within the area utilized for the absorption field, the septic tank effluent may be applied to the absorption field through a system of interconnected tile lines and trenches in a continuous system. The following specific criteria should be followed:

1. A minimum of 12 inches of earth cover is provided over the gravel fill in all trenches of the system.

2. The bottom of the trenches and the distribution lines should be level.

3. One type of a satisfactory absorption system layout for "level" ground is shown in Figure 6, below.

4. Construction considerations for standard trenches, pages 10 through 14, should be followed.

Fields in Sloping Ground.—Serial distribution may be used in all

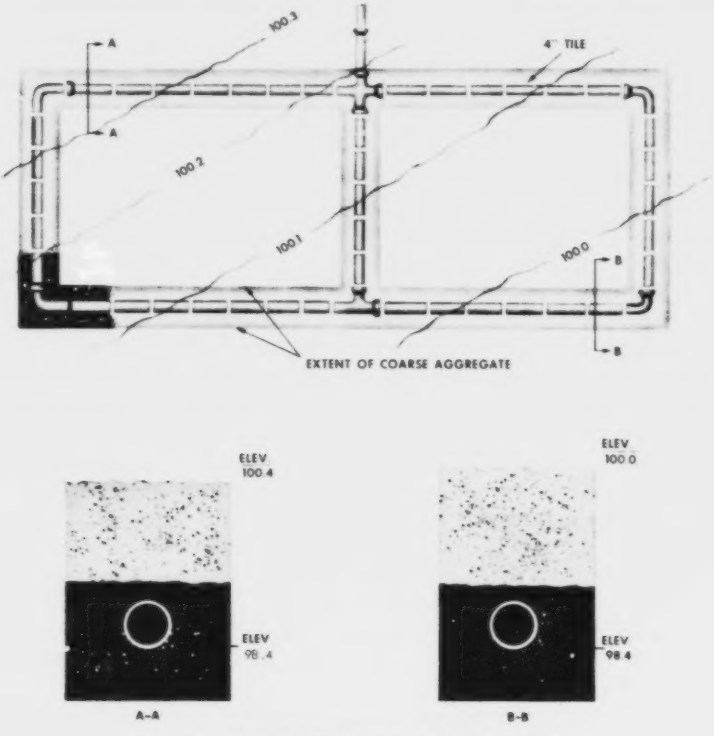


Figure 6.—Absorption-field system for level ground.

situations where a soil absorption system is permitted and and should be used where the fall of the ground surface exceeds approximately 6 inches in any direction within the area utilized for the absorption field. The maximum ground slope suitable for serial distribution systems should be governed by local factors affecting the erosion of the ground used for the absorption field. Excessive slopes which are not protected from surface water runoff or do not have adequate vegetation cover to prevent erosion should be avoided. Generally, ground having a slope greater than one vertical to two horizontal should be investigated carefully to determine if satisfactory from the erosion standpoint. Also, the horizontal distance from side of the trench to the ground surface should be adequate to prevent lateral flow of effluent and breakout on surface and in no case less than two feet.

In serial distribution, each adjacent trench (or pair of trenches) is connected to the next by a closed pipe line laid on an undisturbed section of ground, as shown in Figure 7, page 19. The arrangement is such that all effluent is discharged to the first trench until it is filled. Excess liquid is then carried by means of a closed line to the next succeeding or lower trench. In that manner, each portion of the subsurface system is used in succession. When serial distribution is used, the following design and construction procedures should be followed:

1. The bottom of each trench and its distribution line should be level.

2. There should be a minimum of 12 inches of ground cover over the gravel fill in the trenches.

3. The absorption trenches should follow approximately the ground surface contours so that variations in trench depth will be minimized.

4. There should be a minimum of 6 feet of undisturbed earth between adjacent trenches and between the septic tank and the nearest trench.

5. Adjacent trenches may be connected with the relief line or a drop box arrangement, Figure 7, page 19, in such a manner that each trench is completely filled with septic tank effluent to the full depth of the gravel before effluent flows to succeeding trenches. (The Figure shown does not preclude the use of other arrangements to provide serial distribution.)

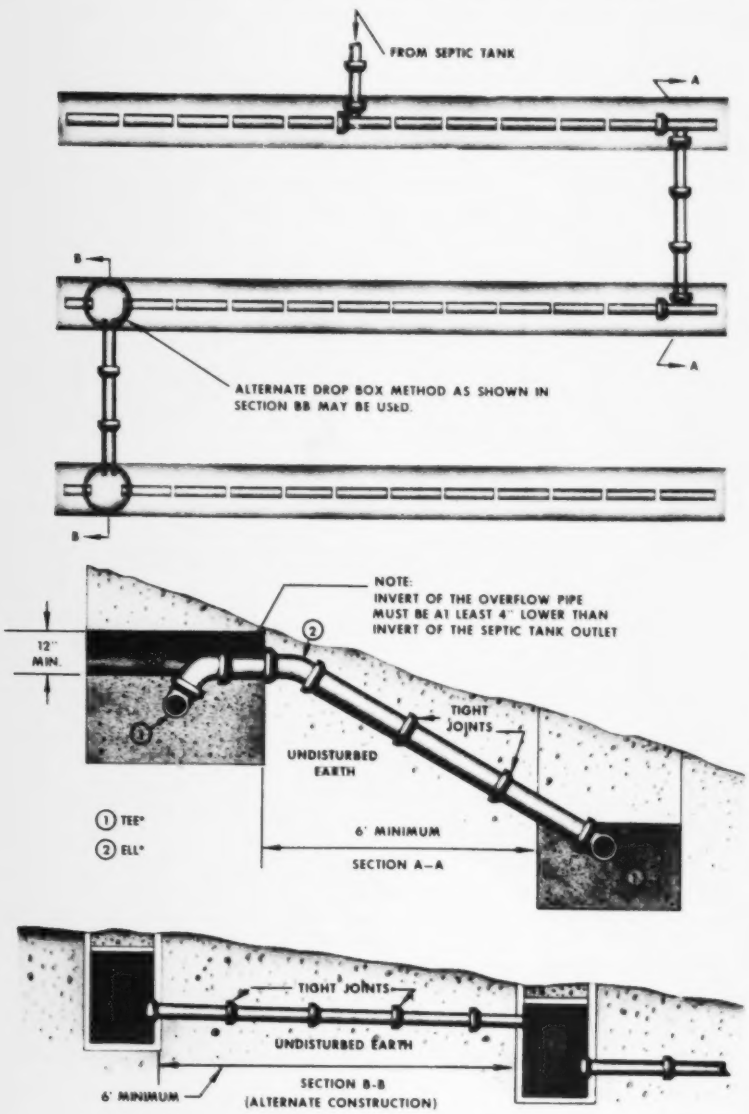
   a. Trench connecting lines should be 4 inch, tight-joint sewers with direct connections to the distribution lines in adjacent trenches or to a drop box arrangement.

   b. Care must be exercised in constructing relief lines to insure an undisturbed block of earth between trenches. The trench for the relief pipe, where it connects with the preceding absorption trench, shall be dug no deeper than the top of the gravel. The relief line should rest on undisturbed earth and backfill should be carefully tamped.

   c. The relief lines connecting individual trenches should be as

far from each other as practicable in order to prevent short circuiting.

6. Invert of the overflow pipe in the first relief line must be at least 4 inches lower than the invert of the septic tank outlet, Figure 7.



* DIFFERING GROUND SLOPES OVER SUBSURFACE DISPOSAL FIELD MAY REQUIRE USE OF VARIOUS COMBINATIONS OF FITTINGS.

Figure 7.—A relief line arrangement for serial distribution.

7. All other construction features of the disposal field are the same as recommended on pages 10 to 14.

Deep Absorption Trenches and Seepage Beds

In cases where the depth of filter material below the tile exceeds the standard six inch depth, credit may be given for the added absorption area provided in deeper trenches with a resultant decrease in length of trench. Such credit shall be given in accordance with Table 3 which gives the percentage of length of standard absorption trench (as computed from Table 1), based on six inch increments of increase in depth of filter material.

Table 3.—*Percentage of length of standard trench* [1]

Depth of Gravel Below Pipe in Inches[2]	Trench width 12″	Trench width 18″	Trench width 24″	Trench width 36″	Trench width 48″	Trench width 60″
12	75	78	80	83	86	87
18	60	64	66	71	75	78
24	50	54	57	62	66	70
30	43	47	50	55	60	64
36	37	41	44	50	54	58
42	33	37	40	45	50	54

[1] The standard absorption trench is one in which the filter material extends two inches above and six inches below the pipe.

[2] For trenches or beds having width not shown in Table 3, the percent of length of standard absorption trench may be computed as follows:

$$\text{Percent of length standard trench} = \frac{w + 2}{w + 1 + 2d} \times 100$$

Where w = width of trench in feet
d = depth of gravel below pipe in feet

To use this table, consider the example on page 12. Using a trench 2 feet wide with 6″ of gravel under tile, 285 feet are required. If the depth of gravel is increased to 18″, keeping trench width at 2 feet, only 66% of 285 feet is required, or 188 feet. If 4 laterals are used, the length would be 188 divided by 4 = 47 feet.

The space between lines for serial distribution on sloping ground is 6 feet × 3 spaces = 18 feet, plus 4 lines × 2 feet = 8 feet. Total land required is 26 feet in width × 47 feet in length = 1,222 square feet, plus additional area required to keep the field away from wells, property lines, etc.

Seepage Pits

Seepage pits, as with all soil absorption systems, should never be used where there is a likelihood of contaminating underground waters, nor where adequate seepage beds or trenches can be provided. When seepage pits are to be used, the pit excavation should terminate 4 feet above the ground water table.

In some States, seepage pits are permitted as an alternative when

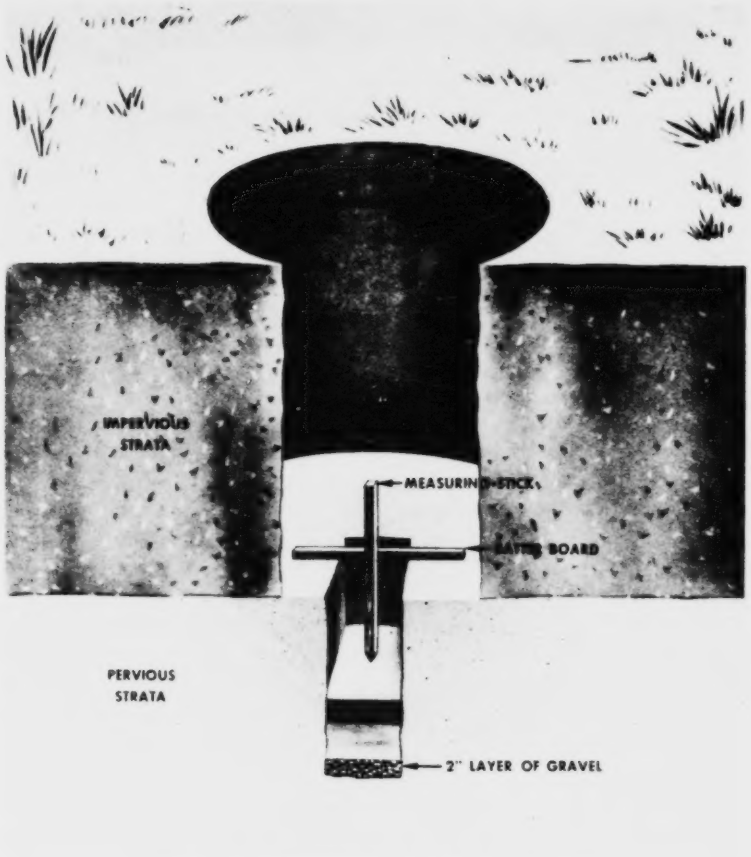
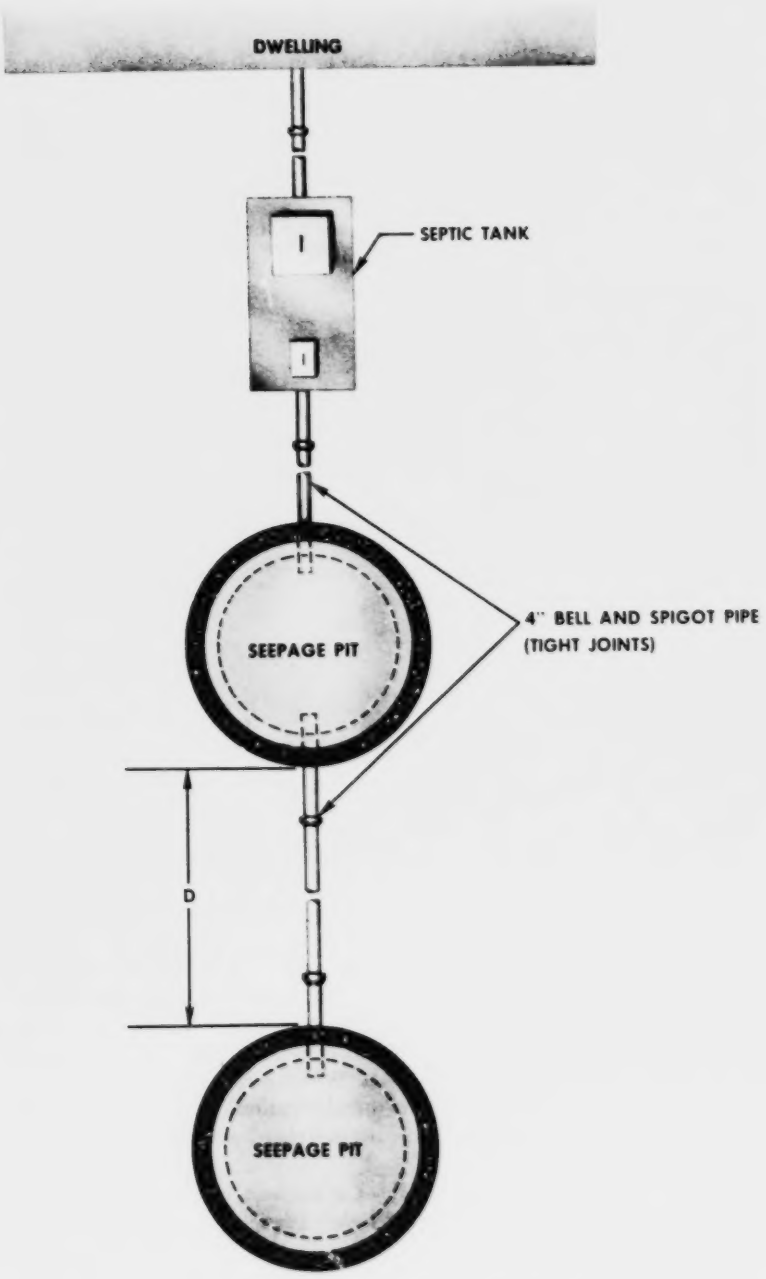


Figure 8.—Deep percolation test for seepage pit.

absorption fields are impracticable, and where the top 3 or 4 feet of soil is underlaid with porous sand or fine gravel and the subsurface conditions are otherwise suitable for pit installations. Where circumstances permit, seepage pits may be either supplemental or alternative to the more shallow absorption fields. When seepage pits are used in combination with absorption fields, the absorption areas in each system should be pro-rated, or based upon the weighted average of the results of the percolation tests.

It is important that the capacity of a seepage pit be computed on the basis of percolation tests made in each vertical stratum penetrated. The weighted average of the results should be computed to obtain a design figure. Soil strata in which the percolation rates are in excess of 30 minutes per inch should not be included in computing the absorption area. As will be apparent from Figure 8 (above), adequate tests



D SHOULD BE AT LEAST 3 TIMES DIAMETER OF SEEPAGE PIT

MINIMUM D AT LEAST 20 FT. FOR PITS OVER 20 FT. IN DEPTH

Figure 9.—Disposal system using two seepage pits.

for deep pits are somewhat difficult to make, time-consuming, and expensive. Although few data have been collected comparing percolation test results with deep pit performance, nevertheless the results of such percolation tests, while of limited value, combined with competent engineering judgment based on experience, are the best means of arriving at design data for seepage pits.

Table 4.—*Vertical wall areas of circular seepage pits*

[In Square Feet]

Diameter of seepage pit (feet)	Effective strata depth below flow line (below inlet)									
	1 foot	2 feet	3 feet	4 feet	5 feet	6 feet	7 feet	8 feet	9 feet	10 feet
3	9.4	19	28	38	47	57	66	75	85	94
4	12.6	25	38	50	63	75	88	101	113	126
5	15.7	31	47	63	79	94	110	126	141	157
6	18.8	38	57	75	94	113	132	151	170	188
7	22.0	44	66	88	110	132	154	176	198	220
8	25.1	50	75	101	126	151	176	201	226	251
9	28.3	57	85	113	141	170	198	226	254	283
10	31.4	63	94	126	157	188	220	251	283	314
11	34.6	69	104	138	173	207	242	276	311	346
12	37.7	75	113	151	188	226	264	302	339	377

Example: A pit of 5 foot diameter and 6 foot depth below the inlet has an effective area of 94 square feet. A pit of 5 foot diameter and 16 foot depth has an area of 94 + 157, or 251 square feet.

Table 1 or Figure 3 (page 9) gives the absorption area requirements per bedroom for the percolation rate obtained. The effective area of the seepage pit is the vertical wall area (based on dug diameter) of the pervious strata below the inlet. No allowance should be made for impervious strata or bottom area. With this in mind, Table 4 may be used for determining the effective side-wall area of circular or cylindrical seepage pits.

Sample Calculations.—Assume that a seepage pit absorption system is to be designed for a 3 bedroom home on a lot where the minimum percolation rate of 1 inch in 15 minutes prevails. According to Table I, 3 × 190 (or 570) square feet of absorption area would be needed. Assume also that the water table does not rise above 27 feet below the ground surface, that seepage pits with effective depth of 20 feet can be provided, and that the house is in a locality where it is common practice to install seepage pits of 5 feet diameter (i.e., 4 feet to the outside walls, which are surrounded by about 6 inches of gravel). Design of the system is as follows:

Let d = depth of pit in feet; D = pit diameter in feet:

$$\pi Dd = 570 \text{ square feet.}$$

$$3.14 \times 5 \times d = 570 \text{ square feet}$$

Solving for d depth of pit = 36 feet (approx.)

In other words, one 5 foot diameter pit 36 feet deep would be needed, but since the maximum effective depth is 20 feet in this particular location, it will be necessary to increase the diameter of the pit, or increase the number of pits, or increase both of these. This is illustrated in the example below:

(a) Design for 2 pits with a 10 foot diameter; d = depth of each pit.

$$2 \times 3.14 \times 10 \times d = 570 \text{ square feet}$$

$$d = 9.1 \text{ feet deep}$$

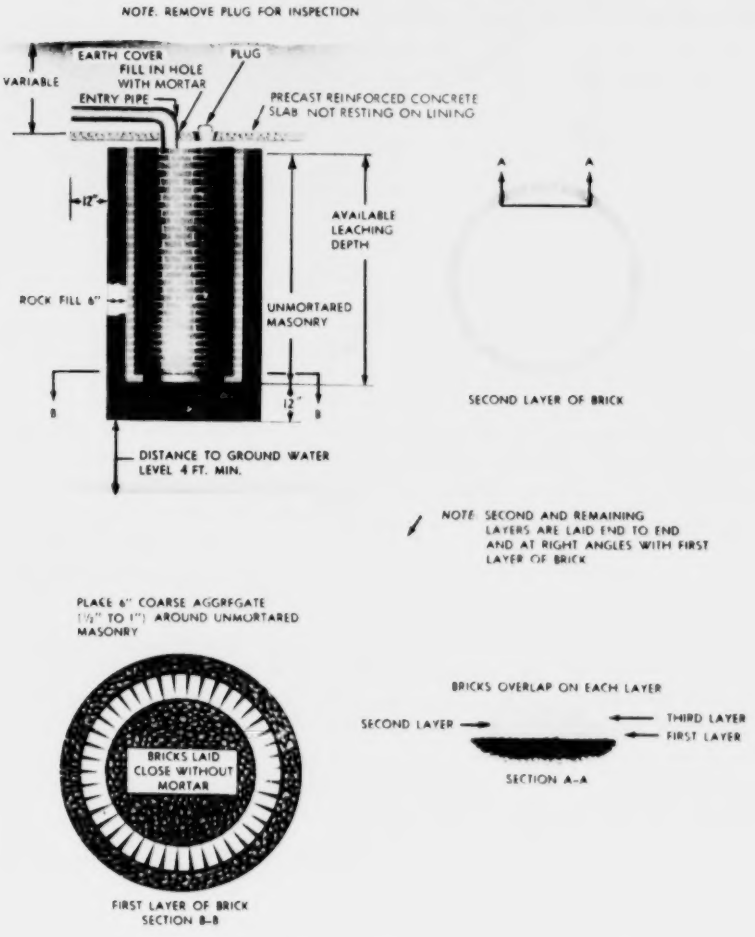


Figure 10.—Seepage pit.

Use 2 pits 10 feet in diameter and 9.1 feet deep.

(b) Design for 2 pits with a 5 foot diameter; d = depth of each pit.

$$2\times 3.14 \times 5 \times d = 570 \text{ square feet}$$
$$d = 18 \text{ feet (approximately)}$$

Use 2 pits 5 feet in diameter and 18 feet deep.

Experience has shown that seepage pits should be separated by a distance equal to 3 times the diameter of the largest pit. For pits over 20 feet in depth, the minimum space between pits should be 20 feet (See Fig. 9, page 22). The area of the lot on which the house is to be built should be large enough to maintain this distance between the pits while still allowing room for additional pits if the first ones should fail. If this can be done, such an absorption system may be approved; if not, other suitable sewerage facilities should be required.

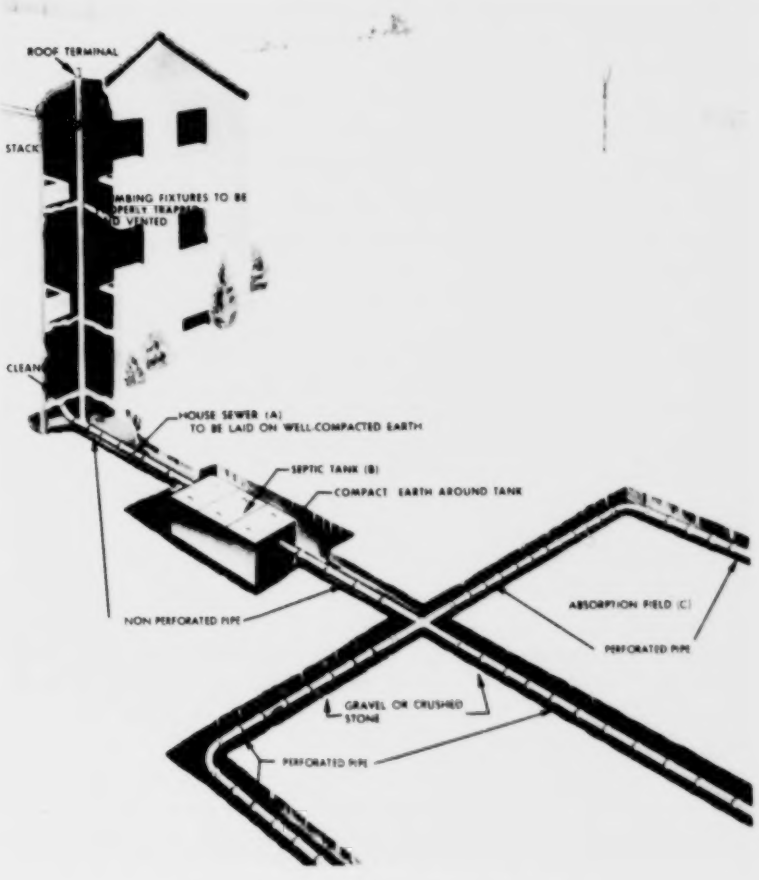


Figure 11.—Septic-tank sewage-disposal system.

Construction Considerations.—Soil is susceptible to damage during excavation. Digging in wet soils should be avoided as much as possible. Cutting teeth on mechanical equipment should be kept sharp. Bucket augered pits should be reamed to a larger diameter than the bucket. All loose material should be removed from the excavation.

Pits should be backfilled with clean gravel to a depth of one foot above the pit bottom or one foot above the reamed ledge to provide a sound foundation for the lining. Preferred lining materials are clay or concrete brick, block, or rings. Rings should have weep holes or notches to provide for seepage. Brick and block should be laid dry with staggered joints. Standard brick should be laid flat to form a four inch wall. The outside diameter of the lining should be at least six inches less than the least excavation diameter. The annular space formed should be filled with clean, coarse gravel to the top of the lining as shown in Figure 10.

Either brick dome or flat concrete covers are satisfactory. They should be based on undisturbed earth and extend at least 12 inches beyond the excavation and should not bear on the lining for structural support. Bricks should be either laid in cement mortar or have a two inch covering of concrete. If flat covers are used, a prefabricated type is preferred, and they should be reinforced to be the equivalent in strength of an approved septic tank cover. A nine inch capped opening in the pit cover is convenient for pit inspection. All concrete surfaces should be located with a protective bitumastic or similar compound to minimize corrosion.

Connecting lines should be of a sound, durable material the same as used for the house to septic tank connection. All connecting lines should be laid on a firm bed of undisturbed soil throughout their length. The grade of a connecting line should be at least two percent. The pit inlet pipe should extend horizontally at least one foot into the pit with a tee or ell to divert flow downward to prevent washing and eroding of the sidewalls. If multiple pits are used, or in the event repair pits are added to an existing system, they should be connected in series.

Abandoned seepage pits should be filled with earth or rock.

SELECTION OF A SEPTIC TANK

Assuming that the lot will be large enough to accommodate one of the types of absorption systems, and that construction of the system is permitted by local authority, the next step will be selection of a suitable septic tank.

Functions of Septic Tanks

Untreated liquid household wastes (sewage) will quickly clog all but the most porous gravel formations. The tank conditions sewage so that it may be more readily percolated into the subsoil of the ground. Thus, the most important function of a septic tank is to provide protection

for the absorption ability of the subsoil. Three functions take place within the tank to provide this protection.

1. *Removal of Solids.*—Clogging of soil with tank effluent varies directly with the amount of suspended solids in the liquid. As sewage from a building sewer enters a septic tank, its rate of flow is reduced so that larger solids sink to the bottom or rise to the surface. These solids are retained in the tank, and the clarified effluent is discharged.

2. *Biological Treatment.*—Solids and liquid in the tank are subjected to decomposition by bacterial and natural processes. Bacteria present are of a variety called anaerobic which thrive in the absence of free oxygen. This decomposition or treatment of sewage under anaerobic conditions is termed "septic," hence the name of the tank. Sewage which has been subjected to such treatment causes less clogging than untreated sewage containing the same amount of suspended solids.

3. *Sludge and Scum Storage.*—Sludge is an accumulation of solids at the bottom of the tank, while scum is a partially submerged mat of floating solids that may form at the surface of the fluid in the tank. Sludge, and scum to a lesser degree, will be digested and compacted into a smaller volume. However, no matter how efficient the process is a residual of inert solid material will remain. Space must be provided in the tank to store this residue during the interval between cleanings; otherwise, sludge and scum will eventually be scoured from the tank and may clog the disposal field.

If adequately designed, constructed, maintained, and operated, septic tanks are effective in accomplishing their purpose.

The relative position of a septic tank in a typical subsurface disposal system is illustrated in Figure 11 (page 25). The liquid contents of the house sewer (A) are discharged first into the septic tank (B), and finally into the subsurface absorption field (C).

The heavier sewage solids settle to the bottom of the tank, forming a blanket of sludge. The lighter solids, including fats and greases, rise to the surface and form a layer of scum. A considerable portion of the sludge and scum are liquefied through decomposition or digestion. During this process, gas is liberated from the sludge, carrying a portion of the solids to the surface, where they accumulate with the scum. Ordinarily, they undergo further digestion in the scum layer, and a portion settles again to the sludge blanket on the bottom. This action is retarded if there is much grease in the scum layer. The settling is also retarded because of gasification in the sludge blanket. Furthermore, there are relatively wider fluctuations of flow in small tanks than in the large units. This effect has been recognized in Table 5 (page 29), which shows the recommended minimum liquid capacities of household septic tanks.

Location.—Septic tanks should be located where they cannot cause contamination of any well, spring, or other source of water supply. Underground contamination may travel in any direction and for con-

siderable distances, unless filtered effectively. Underground pollution usually moves in the same general direction as the normal movement of the ground water in the locality. Ground water moves in the direction of the slope or gradient of the water table, i.e., from the area of higher water table to areas of lower water table. In general, the water table follows the general contour of the ground surface. For this reason, septic tanks should be located downhill from wells or springs. Sewage from disposal systems occasionally contaminate wells having higher surface elevations. Obviously, the elevations of disposal systems are almost always higher than the level of water in such wells as may be located nearby; hence, pollution from a disposal system on a lower *surface* elevation may still travel downward to the water bearing stratum as shown in Figure 12, below. It is necessary, therefore, to rely

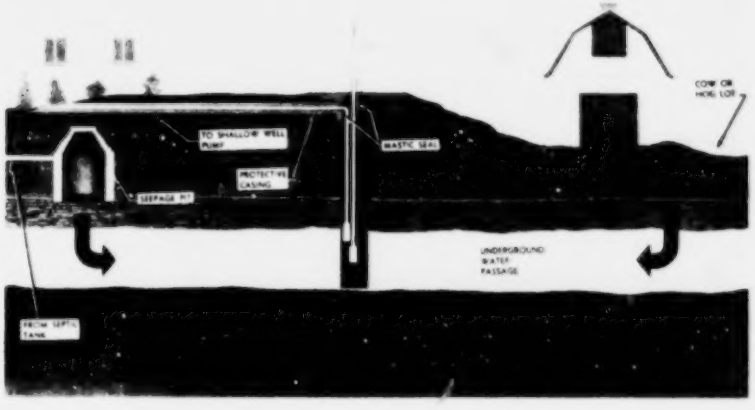


Figure 12.—Pollution of well from sources with lower surface elevations.

upon horizontal as well as vertical distances for protection. Tanks should never be closer than 50 feet from any source of water supply; and greater distances are preferred where possible.

The septic tank should not be located within 5 feet of any building, as structural damage may result during construction or seepage may enter the basement. The tank should not be located in swampy areas, nor in areas subject to flooding. In general, the tank should be located where the largest possible area will be available for the disposal field. Consideration should also be given to the location from the standpoint of cleaning and maintenance. Where public sewers may be installed at a future date, provision should be made in the household plumbing system for connection to such sewer.

Effluent.—Contrary to popular belief, septic tanks do not accomplish a high degree of bacteria removal. Although the sewage undergoes treatment in passing through the tank, this does not mean that infectious agents will be removed; hence, septic tank effluents cannot be considered safe. The liquid that is discharged from a tank is, in some respects, more objectionable than that which goes in; it is septic and malodorous. This, however, does not detract from the value of the tank. As previously explained, its primary purpose is to condition the sewage so that it will cause less clogging of the disposal field.

Further treatment of the effluent, including the removal of pathogens, is effected by percolation through the soil. Disease producing bacteria will, in time, die out in the unfavorable environment afforded by soil. In addition, bacteria are also removed by certain physical forces during filtration. This combination of factors results in the eventual purification of the sewage effluent.

Capacity.—Capacity is one of the most important considerations in septic tank design. Studies have proved that liberal tank capacity is not only important from a functional standpoint, but is also good economy. The liquid capacities recommended in Table 5 allow for the use of all household appliances, including garbage grinders.

Table 5.—*Liquid capacity of tank (gallons)*

[Provides for use of garbage grinders, automatic clothes washers, and other household appliances]

Number of bedrooms	Recommended minimum tank capacity	Equivalent capacity per bedroom
2 or less	750	375
3	900	300
4[1]	1,000	250

[1] For each additional bedroom, add 250 gallons.

Specifications for Septic Tanks

Materials.—Septic tanks should be watertight and constructed of materials not subject to excessive corrosion or decay, such as concrete, coated metal, vitrified clay, heavyweight concrete blocks, or hard burned bricks. Properly cured precast and cast-in-place reinforced concrete tanks are believed to be acceptable everywhere. Steel tanks meeting Commercial Standard 177–62 of the U. S. Department of Commerce are generally acceptable. Special attention should be given to job built tanks to insure water tightness. Heavyweight concrete block should be laid on a solid foundation and mortar joints should be well filled. The interior of the tank should be surfaced with two ¼ inch thick coats of

portland cement-sand plaster. Some typical septic tanks are illustrated in Figure 13 (page 31). Suggested specifications for watertight concrete are given in Appendix E.

Precast tanks should have a minimum wall thickness of 3 inches, and should be adequately reinforced to facilitate handling. When precast slabs are used as covers, they should be watertight, have a thickness of at least 3 inches, adequately reinforced. All concrete surfaces should be coated with a bitumastic or similar compound to minimize corrosion.

General.—Backfill around septic tanks should be made in thin layers thoroughly tamped in a manner that will not produce undue strain on the tank. Settlement of backfill may be done with the use of water, provided the material is thoroughly wetted from the bottom upwards and the tank is first filled with water to prevent floating.

Adequate access must be provided to each compartment of the tank for inspection and cleaning. Both the inlet and outlet devices should be accessible. Access should be provided to each compartment by means of either a removable cover or a 20 inch manhole in least dimension. Where the top of the tank is located more than 18 inches below the finished grade, manholes and inspection holes should extend to approximately 8 inches below the finished grade (see Figure 14, page 32), or can be extended to finished grade if a seal is provided to keep odors from escaping. In most instances, the extension can be made using clay or concrete pipe, but proper attention must be given to the accident hazard involved when manholes are extended close to the ground surface. Typical single and double compartment tanks are illustrated in Figures 15 and 17, pages 33 and 35.

Inlet.—The inlet invert should enter the tank at least 3 inches above the liquid level in the tank, to allow for momentary rise in liquid level during discharges to the tank. This free drop prevents backwater and stranding of solid material in the house sewer leading to the tank.

A vented inlet tee or baffle should be provided to divert the incoming sewage downward. It should penetrate at least 6 inches below the liquid level, but in no case should the penetration be greater than that allowed for the outlet device. A number of arrangements commonly used for inlet and outlet devices are shown in Figure 16 (page 34).

Outlet.—It is important that the outlet device penetrate just far enough below the liquid level of the septic tank to provide a balance between sludge and scum storage volume; otherwise, part of the advantage of capacity is lost. A vertical section of a properly operating tank would show it divided into three distinct layers: scum at the top, a middle zone free of solids (called "clear space"), and a bottom layer of sludge. The outlet device retains scum in the tank, but at the same time, it limits the amount of sludge that can be accommodated without scouring, which results in sludge discharging in the effluent from the tank. Observations of sludge accumulations in the field, as

Figure 13.—Typical septic-tank shapes.

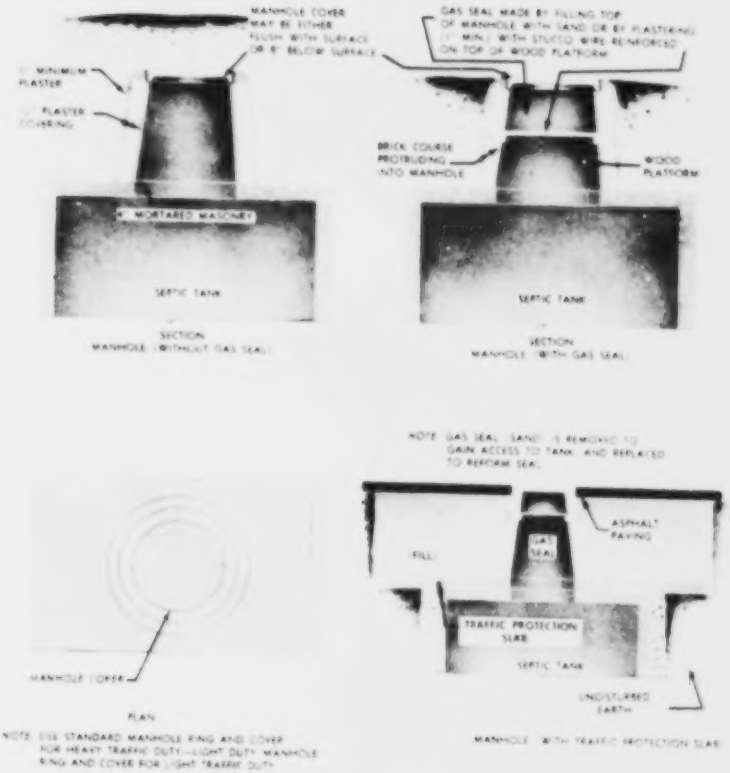


Figure 14.—Design of manholes.

reported in Section B, Part III, of "Studies on Household Sewage Disposal Systems" (bibliography reference, page 92), indicate that the outlet device should generally extend to a distance below the surface equal to 40 percent of the liquid depth. For horizontal, cylindrical tanks, this should be reduced to 35 percent. For example, in a horizontal cylindrical tank having a liquid depth of 42 inches, the outlet device should penetrate $12 \times .35 = 14.7$ inches below the liquid level.

The outlet device should extend above the liquid line to approximately one inch from the top of the tank. The space between the top of the tank and the baffle allows gas to pass off through the tank into the house vent.

Tank Proportions.—The available data indicate that, for tanks of a given capacity, shallow tanks function as well as deep ones. Also, for tanks of a given capacity and depth, the shape of a septic tank is unimportant. However, it is recommended that the smallest plan dimension be at least 2 feet. Liquid depth may range between 30 and 60 inches.

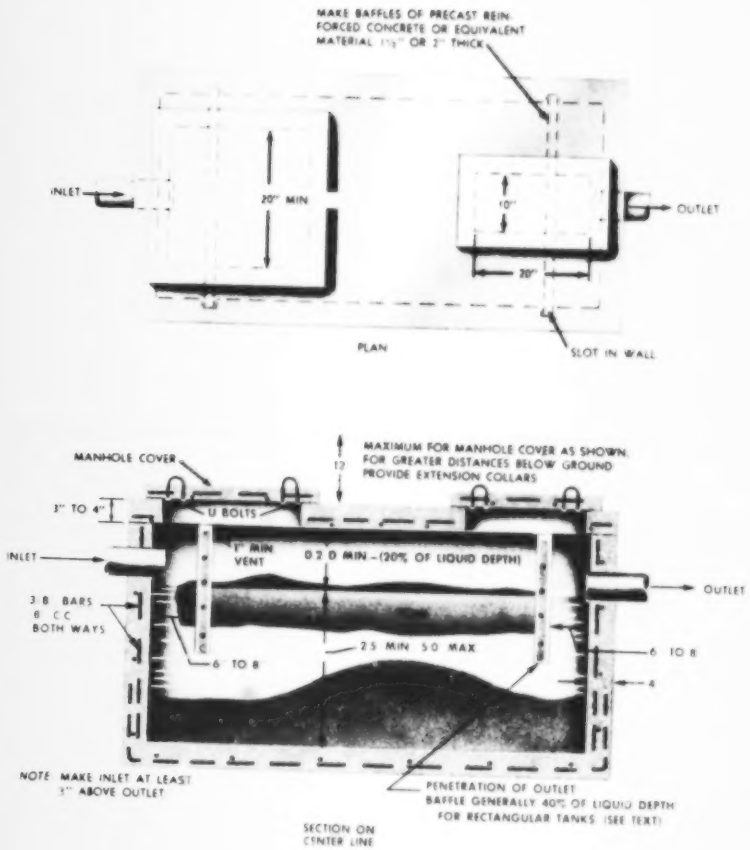


Figure 15.—Household septic tank.

Storage Above Liquid Level.—Capacity is required above the liquid line to provide for that portion of the scum which floats above the liquid. Although some variation is to be expected, on the average about 30 percent of the total scum will accumulate above the liquid line. In addition to the provision for scum storage, one inch is usually provided at the top of the tank to permit free passage of gas back to the inlet and house vent pipe.

For tanks having straight, vertical sides, the distances between the top of the tank and the liquid line should be equal to approximately 20 percent of the liquid depth. In horizontal, cylindrical tanks, area equal to approximately 15 percent of the total circle should be provided above the liquid level. This condition is met if the liquid depth (distance from outlet invert to bottom of tank) is equal to 79 percent of the diameter of the tank.

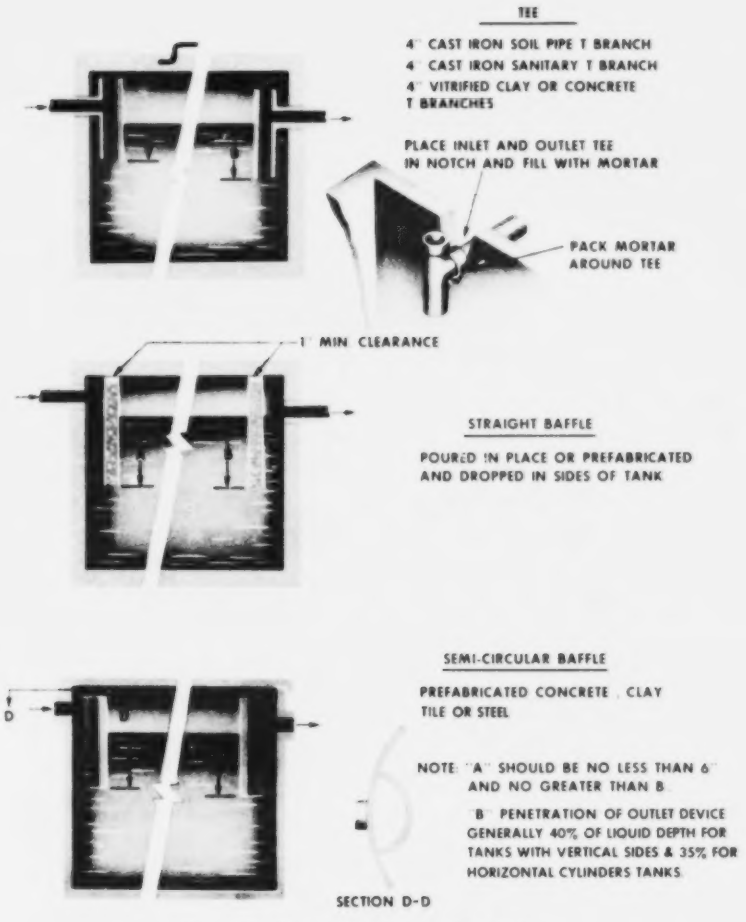

TEE
4" CAST IRON SOIL PIPE T BRANCH
4" CAST IRON SANITARY T BRANCH
4" VITRIFIED CLAY OR CONCRETE T BRANCHES
PLACE INLET AND OUTLET TEE IN NOTCH AND FILL WITH MORTAR
PACK MORTAR AROUND TEE
1" MIN CLEARANCE
STRAIGHT BAFFLE
POURED IN PLACE OR PREFABRICATED AND DROPPED IN SIDES OF TANK
SEMI-CIRCULAR BAFFLE
PREFABRICATED CONCRETE, CLAY TILE OR STEEL
NOTE: "A" SHOULD BE NO LESS THAN 6" AND NO GREATER THAN B
"B" PENETRATION OF OUTLET DEVICE GENERALLY 40% OF LIQUID DEPTH FOR TANKS WITH VERTICAL SIDES & 35% FOR HORIZONTAL CYLINDERS TANKS
D
SECTION D-D

Figure 16.—Types of inlet and outlet devices.

Use of Compartments.—Although a number of arrangements are possible, compartments, as used here, refer to a number of units in series. These can be either separate units linked together, or sections enclosed in one continuous shell (as in Figure 17, page 35, with watertight partitions separating the individual compartments.

A single compartment tank will give acceptable performance. The available research data indicate, however, that a two compartment tank, with the first compartment equal to one-half to two-thirds of the total volume, provides better suspended solids removal which may be especially valuable for protection of the soil absorption system. Tanks with three or more equal compartments give at least as good performance as single compartment tanks of the same total capacity.

Each compartment should have a minimum plan dimension of 2 feet with a liquid depth ranging from 30 to 60 inches.

An access manhole should be provided to each compartment. Venting between compartments should be provided to allow free passage of gas. Inlet and outlet fittings in the compartmented tank should be proportioned as for a single tank. (See Figure 16, page 34). The same allowance should be made for storage above the liquid line as in a single tank.

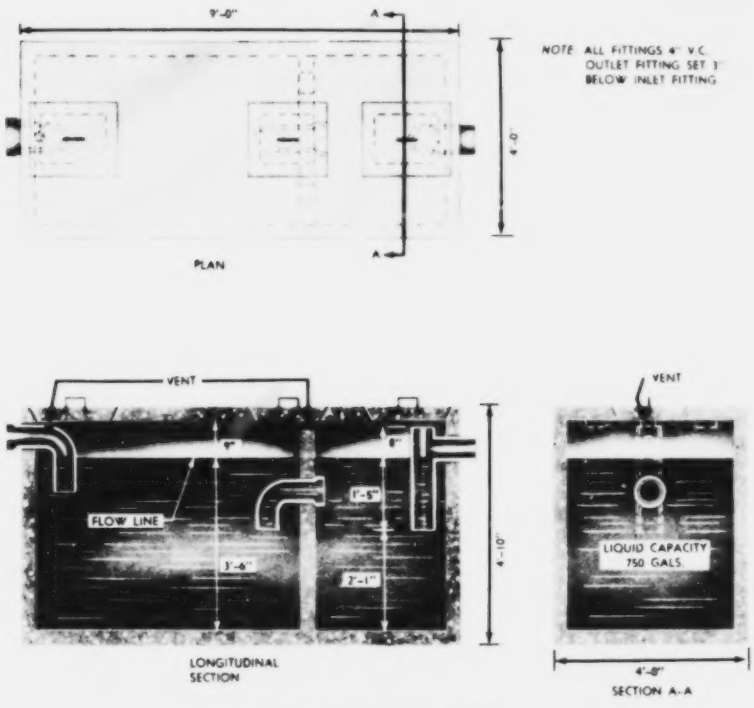


Figure 17.—Precast septic tank.

General Information on Septic Tanks

Cleaning.—Septic tanks should be cleaned before too much sludge or scum is allowed to accumulate. If either the sludge or scum approaches too closely to the bottom of the outlet device, particles will be scoured into the disposal field and will clog the system. Eventually, when this happens, liquid may break through to the ground surface, and the sewage may back up in the plumbing fixtures. When a disposal field is clogged in this manner, it is not only necessary to clean the tank, but it also may be necessary to construct a new disposal field.

The tank capacities given in Table 5 on page 29 will give a reason-

able period of good operation before cleaning becomes necessary. There are wide differences in the rate that sludge and scum will accumulate from one tank to the next. For example, in one case out of 20, the tank will reach the danger point, and should be cleaned, in less than 3 years. *Tanks should be inspected at least once a year and cleaned when necessary.*

Although it is difficult for most homeowners, actual inspection of sludge and scum accumulations is the only way to determine definitely when a given tank needs to be pumped. When a tank is inspected, the depth of sludge and scum should be measured in the vicinity of the outlet baffle. The tank should be cleaned if either: (a) The bottom of the scum mat is within approximately 3 inches of the bottom of the outlet device; or (b) sludge comes within the limits specified in Table 6 (see Figure 18, page 37).

Table 6.—*Allowable sludge accumulation*

Liquid capacity of tank, gallons*	Liquid depth			
	2½ feet	3 feet	4 feet	5 feet
	Distance from bottom of outlet device to top of sludge, inches			
750	5	6	10	13
900	4	4	7	10
1,000	4	4	6	8

* Tanks smaller than the capacities listed will require more frequent cleaning.

Scum can be measured with a stick to which a weighted flap has been hinged, or with any device that can be used to feel out the bottom of the scum mat. The stick is forced through the mat, the hinged flap falls into a horizontal position, and the stick is raised until resistance from the bottom of the scum is felt. With the same tool, the distance to the bottom of the outlet device can be found (see Figure 18, page 37).

A long stick wrapped with rough, white toweling and lowered to the bottom of the tank will show the depth of sludge and the liquid depth of the tank. The stick should be lowered behind the outlet device to avoid scum particles. After several minutes, if the stick is carefully removed, the sludge line can be distinguished by sludge particles clinging to the toweling.

In most communities where septic tanks are used, there are firms which conduct a business of cleaning septic tanks. The local health department can make suggestions on how to obtain this service.

Cleaning is usually accomplished by pumping the contents of the tank into a tank truck. *Tanks should not be washed or disinfected after pumping.* A small residual of sludge should be left in the tank for seeding purposes. The material removed may be buried in uninhabited places or, with permission of the proper authority, emptied into a sanitary sewer system. It should never be emptied into storm drains or discharged directly into any stream or watercourse. Methods of disposal should be approved by the health authorities.

When a large septic tank is being cleaned, care should be taken not to enter the tank until it has been thoroughly ventilated and gases have been removed to prevent explosion hazards or asphyxiation of the workers. Anyone entering the tank should have one end of a stout rope tied around his waist, with the other end held above ground

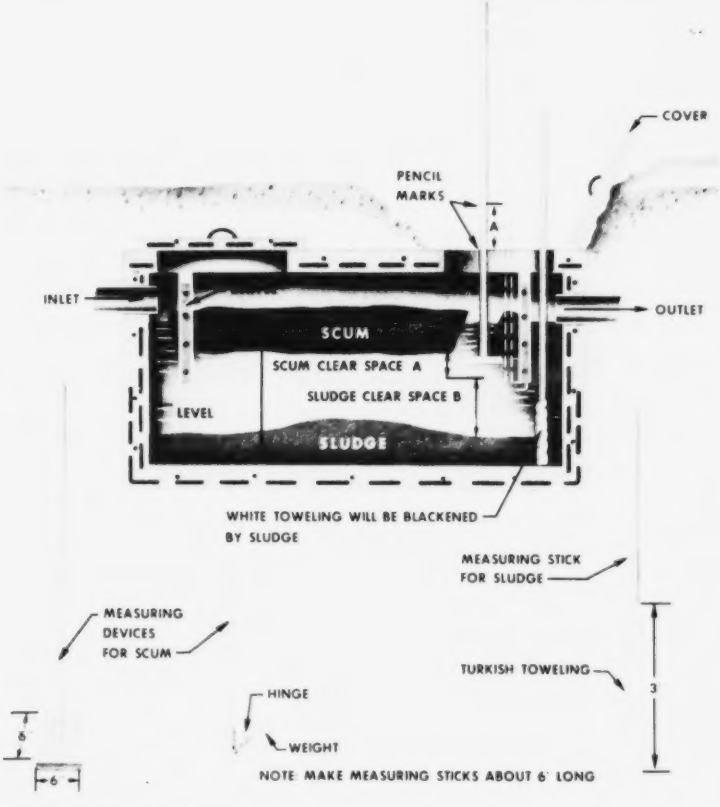


Figure 18.—Devices for measuring sludge and scum.

by another person strong enough to pull him out if he should be overcome by any gas remaining in the tank.

Grease Interceptors.—Grease interceptors (grease traps) are not ordinarily considered necessary on household sewage disposal systems. The discharge from a garbage grinder should never be passed through them. The septic tank capacities recommended in this manual are sufficient to receive the grease normally discharged from a home.

Chemicals.—The functional operation of septic tanks is not improved by the addition of disinfectants or other chemicals. In general, the addition of chemicals to a septic tank is not recommended. Some proprietary products which are claimed to "clean" septic tanks contain sodium hydroxide or potassium hydroxide as the active agent. Such compounds may result in sludge bulking and a large increase in alkalinity, and may interfere with digestion. The resulting effluent may severely damage soil structure and cause accelerated clogging, even though some temporary relief may be experienced immediately after application of the product.

Frequently, however, the harmful effects of ordinary household chemicals are overemphasized. Small amounts of chlorine bleaches, added ahead of the tank, may be used for odor control and will have no adverse effects. Small quantities of lye or caustics normally used in the home, added to plumbing fixtures is not objectionable as far as operation of the tank is concerned. If the septic tanks are as large as herein recommended, dilution of the lye or caustics in the tank will be enough to overcome any harmful effects that might otherwise occur.

Some 1,200 products, many containing enzymes, have been placed on the market for use in septic tanks, and extravagant claims have been made for some of them. As far as is known, however, none has been proved of advantage in properly controlled tests.

Soaps, detergents, bleaches, drain cleaners, or other material, as normally used in the household, will have no appreciable adverse effect on the system. However, as both the soil and essential organisms might be susceptible to large doses of chemicals and disinfectants, moderation should be the rule. Advice of responsible officials should be sought before chemicals arising from a hobby or home industry are discharged into the systems.

Miscellaneous.—It is generally advisable to have all sanitary wastes from a household discharge to a single septic tank and disposal system. For household installations, it is usually more economical to provide a single disposal system than two or more with the same total capacity. Normal household waste, including that from the laundry, bath, and kitchen, should pass into a single system.

Roof drains, foundation drains and drainage from other sources producing large intermittent or constant volumes of clear water should not be piped into the septic tank or absorption area. Such large volumes of water will stir up the contents of the tank and carry some of the

solids into the outlet line; the disposal system following the tank will likewise become flooded or clogged, and may fail. Drainage from garage floors or other sources of oily waste should also be excluded from the tank.

Toilet paper substitutes should not be flushed into a septic tank. Paper towels, newspaper, wrapping paper, rags, and sticks may not decompose in the tank, and are likely to lead to clogging of the plumbing and disposal system.

Waste brines from household water softener units have no adverse effect on the action of the septic tank, but may cause a slight shortening of the life of a disposal field installed in a structured clay type soil.

Adequate venting is obtained through the building plumbing if the tank and the plumbing are designed and installed properly. A separate vent on a septic tank is not necessary.

A chart showing the location of the septic tank and disposal system should be placed at a suitable location in dwellings served by such a system. Whether furnished by the builder, septic tank installer, or the local health department, the charts should contain brief instructions as to the inspection and maintenance required. The charts should assist in acquainting homeowners of the necessary maintenance which septic tanks require, thus forestalling failures by assuring satisfactory operation. The extension of the manholes or inspection holes of the septic tank to within 8 inches of the ground surface will simplify maintenance and cleaning.

Abandoned septic tanks should be filled with earth or rock.

INSPECTION

After a soil absorption system has been installed and before it is used the entire system should be tested and inspected. The septic tank should be filled with water and allowed to stand overnight to check for leaks. If leaks occur, they should be repaired. The soil absorption system should be promptly inspected before it is covered to be sure that the disposal system is installed properly. Prompt inspection before backfilling should be required by local regulations, even where approval of plans for the subsurface sewage disposal system has been required before issuance of a building permit. Backfill material should be free of large stones and other deleterious material and should be overfilled a few inches to allow for settling.

Part II

Septic Tank - Soil Absorption Systems for Institutions, Recreational Areas, and Other Establi hments

INTRODUCTION

The septic tank system is utilized in providing sewage treatment and disposal for many types of establishments, such as schools, small institutions, motels, rural hotels and restaurants, trailer parks, housing projects, large private estates, and camps, where larger quantities of sewage are involved than are discharged from an individual home. In general, the usefulness of the septic tank system decreases as the size of the establishment served increases. Lack of competent sanitary engineering advice in the development of such systems generally will lead to failures, excessive costs, and a multitude of troubles. The soundest advice available to anyone contemplating such a system is the early retention of competent sanitary engineering consultation, whose first determination should be the suitability of this method of sewage disposal for the proposed establishment.

Any institutional septic tank system must incorporate appurtenances and supplemental features of design to meet the requirements of the establishment and varying site conditions. These can be generally successful when appropriate experience, study, and planning are employed in the choice and development of such a system. This manual cannot present all of the results of experience gained in the design and operation of such systems, but describes the most generally successful procedures and practices as a guide to engineers designing them.

While many effluents from institutional septic tanks are disposed of by soil absorption methods, others are discharged to available watercourses after suitable treatment. When soil absorption systems are contemplated, it is essential, as described in Part I, to determine the characteristics and suitability of the soil as the first step toward design. As a matter of fact, the wise builder of an establishment will explore this feature on a contemplated site before the site is purchased. After the

percolation tests are completed, the quantity of sewage to be treated must be estimated to determine the size and capacities of the disposal units.

ESTIMATES OF SEWAGE QUANTITIES

Where there are water meters in existing buildings, the quantity of sewage may best be estimated from the recorded meter readings.

In using water meter readings for estimating the quantity of sewage to be contributed, some allowance should also be made for maximum conditions that may not be readily apparent from the readings. For example, water consumption by an ordinary family of four in an apartment building may average 48 gallons of water per person per day over a period of 3 months, but actually range from perhaps 30 gallons per person on certain days to something in excess of 80 gallons per person on days when water consumption is heaviest, as on washdays. Besides these peak loads, some allowance should be made for the sewage contributed by occasional guests. Therefore, when computing sewage flows from *average* meter readings, a minimum factor of safety of about 25 percent should be allowed to cover the range of variations. Accordingly, the design of a disposal system for the apartment house referred to, where the average usage is 48 gallons per person per day, should be based upon a computed maximum usage of at least 60 gallons per person per day.

Conversely, unusually high meter readings may be caused by lawn sprinkling or by leakage of water that does not enter the disposal system. Due allowances should be made for abnormalities of this kind.

Where measurements of water consumption are not possible, as where water meter records are not available, or where disposal facilities are being planned for a new building, it is necessary to use other methods of estimating the amount of sewage to be discharged. One way is to base the estimated flow on the number of bedrooms, as in Part I. Another way is to compute the flow on the basis of the number and kinds of plumbing fixtures. If the building is used as a restaurant, the number of patrons or the number of meals served may be the best criterion. The competent designer will base his estimates upon a combination of the various influencing factors. He will consider each case on its own merits, especially when disposal facilities are being designed for a large institution where the cost of construction will amount to a considerable sum. If definite information and accurate water measurements are not available, the quantity of sewage may be estimated from experiences at establishments similar to that for which the new sewage disposal facilities are intended. Table 7 (page 43) may be helpful in such cases.

The quantities listed in the table are merely the best averages available at this time, and they should be modified in localities or establishments where experience indicates a need for so doing.

It is sometimes economical and advisable to construct separate disposal systems for different types of wastes at a given establishment. The decision as to the number of disposal systems may be influenced by conditions of terrain, topography, and locations of the buildings contributing to the wastes. At large camps, for example, and at some resorts, kitchens and central dining facilities may be located at appreciable distances from the barracks or cottages and cabins. Under such circumstances, the kitchens may be provided with separate disposal systems, including facilities for the removal of grease ahead of the septic tank.

Table 7.—*Quantities of sewage flows*

Type of Establishment	Gallons Per Person Per Day (Unless Otherwise Noted)
Airports (per passenger)	5
Apartments—multiple family (per resident)	60
Bathhouses and swimming pools	10
Camps:	
Campground with central comfort stations	35
With flush toilets, no showers	25
Construction camps (semi-permanent)	50
Day camps (no meals served)	15
Resort camps (night and day) with limited plumbing	50
Luxury camps	100
Cottages and small dwellings with seasonal occupancy	50
Country clubs (per resident member)	100
Country clubs (per non-resident member present)	25
Dwellings:	
Boarding houses	50
additional for non-resident boarders	10
Luxury residences and estates	150
Multiple family dwellings (apartments)	60
Rooming houses	40
Single family dwellings	75
Factories (gallons per person, per shift, exclusive of industrial wastes)	35
Hospitals (per bed space)	250+
Hotels with private baths (2 persons per room)	60
Hotels without private baths	50
Institutions other than hospitals (per bed space)	125
Laundries, self-service (gallons per wash, i.e., per customer)	50
Mobile home parks (per space)	250
Motels with bath, toilet, and kitchen wastes (per bed space)	50
Motels (per bed space)	40
Picnic Parks (toilet wastes only) (per picknicker)	5
Picnic parks with bathhouses, showers, and flush toilets	10
Restaurants (toilet and kitchen wastes per patron)	10

Table 7.—Continued

Type of Establishment	Gallons Per Person Per Day (Unless Otherwise Noted)
Restaurants (kitchen wastes per meal served)	3
Restaurants additional for bars and cocktail lounges	2
Schools:	
Boarding	100
Day, without gyms, cafeterias, or showers	15
Day, with gyms, cafeteria, and showers	25
Day, with cafeteria, but without gyms, or showers	20
Service stations (per vehicle served)	10
Swimming pools and bathhouses	10
Theaters:	
Movie (per auditorium seat)	5
Drive-in (per car space)	5
Travel trailer parks without individual water and sewer hook-ups (per space)	50
Travel trailer parks with individual water and sewer hook-ups (per space)	100
Workers:	
Construction (at semi-permanent camps)	50
Day, at schools and offices (per shift)	15

Separate systems may also be used for community bathhouses. When this is done, the total per capita flow must be broken down into its component parts, and some allowance should be made for the amount of sewage tributary to the different disposal systems. Table 8 (below) illustrates how this may be done where there are no definite data as to the exact distribution of flow.

Table 8.—*Estimated distribution of sewage flows, in gallons per day per person*

Type of Waste	Volume, gallons per day per person				
Total Flow (gallons)	30	40	50	75	100
Kitchen wastes	[1] 0	7	10	10	15
Toilet wastes	15	15	20	25	30
Showers, washbasins, etc.	15	18	20	25	35
Laundry wastes	[1] 0	[1] 0	[1] 0	15	20

[1] No wastes from these uses.

Example: In a household contributing 75 gallons of sewage per day per person, as shown in column 4, an average breakdown for each of the four types of wastes listed might be about 10 gallons per day per person for kitchen wastes; 25 gallons

per day per person for toilet wastes; 25 gallons per day per person for shower wastes, bathtubs, and washbasins; and about 15 gallons per day per person for laundry wastes.

For certain types of new establishments, the designing engineer may be unable to obtain from his clients accurate estimates as to the number of patrons to be served by the disposal facilities. This is particularly true in the case of restaurants and at recreational places, such as picnic areas, country clubs, and the like. In such cases, computations and estimates may best be made from the number of plumbing fixtures installed. Table 9 indicates average values for quantities of sanitary wastes per fixture at country clubs with modern plumbing.

Table 9.—*Sewage flow from country clubs*

Type of fixture	Gallons per day per fixture	Type of fixture	Gallons per day per fixture
Showers	500	Toilets	150
Baths	300	Urinals	100
Lavatories	100	Sinks	50

Estimates of sewage quantities from golf clubs should be checked and calculations based on the weekend population. Allowances of 10 gallons per person for showers and 7 gallons per person for toilet and kitchen wastes, both for the average weekend population, have been found reasonable.

Table 10 shows one method used in estimating the amount of sewage discharged hourly during the hours when public parks are open. Similar figures may be used for fairgrounds, carnivals, ball parks, etc.

Table 10.—*Sewage flow at public parks*

[During hours when park is open]

Type of fixture	Gallons per hour per fixture	Type of fixture	Gallons per hour per fixture
Flush toilets	36	Showers	100
Urinals	10	Faucets	15

ESTIMATES OF SOIL ABSORPTION AREAS

With information from percolation tests and with due consideration to the results of test borings or subsurface explorations, as explained in

Part I and Appendix A, the rate at which sewage may be applied to a soil absorption system may be taken from Table 11 or from the corresponding curve in Figure 19 (see page 47).

Table 11.—*Allowable rate of sewage application to a soil absorption system*

Percolation rate (time in minutes for water to fall 1 inch)	Maximum rate of sewage application (gallons per square foot per day)[1] for absorption trenches,[2] seepage beds, and seepage pits[3]	Percolation rate (time in minutes for water to fall 1 inch)	Maximum rate of sewage application (gallons per square foot per day)[1] for absorption trenches,[2] seepage beds, and seepage pits[3]
1 or less	5.0	10	1.6
2	3.5	15	1.3
3	2.9	30[4]	0.9
4	2.5	45[4]	0.8
5	2.2	60[4,5]	0.6

[1] Not including effluents from septic tanks that receive wastes from garbage grinders and automatic washing machines.

[2] Absorption area is figured as trench bottom area, and includes a statistical allowance for vertical sidewall area.

[3] Absorption area for seepage pits is effective sidewall area.

[4] Over 30 unsuitable for seepage pits.

[5] Over 60 unsuitable for absorption systems.

Table 11 and the curves in Figure 19 do not allow for wastes from garbage grinders and automatic washing machines. Discharge from these appliances to an institutional septic tank system calls for extra capacity of 20 and 40 percent, respectively, over the calculated absorption area values. If both of these appliances are installed, the absorption area should be increased by about 60 percent over the calculated value. Part I allowed for these types of waste in giving specifications for small household systems, but they may never occur in institutional effluents, such as those from factories and offices. Other institutions, such as a country club or drive-in theatre with eating facilities, may contribute wastes from garbage grinders, but not from automatic washing machines. As previously emphasized, all institutions should have their systems designed by an engineer who is competent to place proper evaluations on the kind of wastes to be contributed.

Use of Table 11 is demonstrated in the following examples, which illustrates the design for the two types of soil absorption systems. For each example assume: 5,000 gallons of sewage per day to be disposed of; percolation rate, 1 inch in 5 minutes.

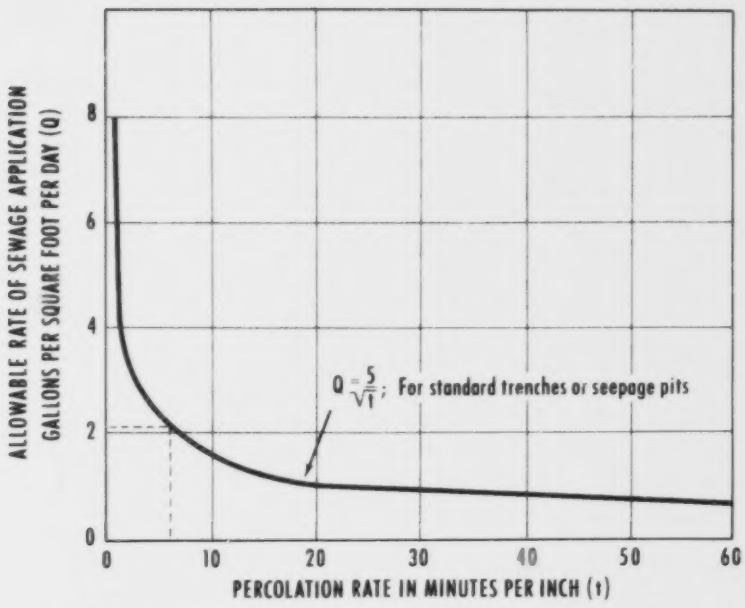


Figure 19.—Graph showing relation between percolation rate and allowable rate of sewage application.

Example I.—Absorption Trenches:

Standard trench, 2 feet width.

5,000 gal./ day ÷ 2.2 gal./sq. ft. day = 2,270 square feet of absorption area required.

2,270 ÷ 2 sq. ft./linear ft. = 1,135 feet of trench required.

With garbage grinder only—1,135 + .20 (1,135) = 1,362 linear feet.

With automatic washing machine only—1,135 + .40 (1,135) = 1,589 linear feet

With garbage grinder and automatic washing machine—1,135 + .60 (1,135) = 1,816 linear feet.

Example II.—Seepage Pits:

Seepage pit 10 foot diameter; depth of effective absorption area 25 feet; let d = effective depth of pit in feet; D equal pit diameter in feet. Effective sidewall area equals total area needed.

$\pi D(d) = 2{,}270$ sq. ft.

3.14 (10) (d) = 2,270.

Solve for d, effective depth of pit = 72 ft.

Obviously, more than one pit is required.

Design for 3 pits, 10 ft. in diameter.

72 ÷ 3 = 24 ft.

Use 3 pits, 10 ft. in diameter with an effective depth of 24 ft.

With garbage grinder only—3.14 (10) (d) = 2,270 + 2,270 (.20) = 2,724 sq. ft.

Solve for d = 86.4 ft. Use 4 pits, 10 ft. in diameter with an effective depth of 21.6 ft.

With automatic washing machine only—3.14 (10) (d) = 2,270 + 2,270 (.40) = 3,178 sq. ft. Solve for d = 101 ft. needed. Use 5 pits, 10 ft. in diameter with an effective depth of 20.2 ft.

With garbage grinder and automatic washing machine—3.14 (10) (d) = 2,270 + 2,270 (.60) = 3,632 sq. ft. required. Solve for d = 115.7 ft. required. Use 5 pits, 10 ft. in diameter with an effective depth of 23.1 ft.

BUILDING SEWERS

The building sewer or house sewer is the pipeline carrying sewage from the building or house drain to a private sewer, public sewer, septic tank, or other point of disposal. It usually extends from a point 3 feet outside the building, where it is connected to the building drain.

The building sewer should be constructed of cast iron, vitrified clay, concrete, bituminized fiber, asbestos cement, or other durable material. All joints in the sewer line should be watertight and rootproof. The grade of the building sewer should be at least 2 percent (2 foot fall per 100 feet, or ¼ inch per foot) except for the 10 feet immediately preceding the septic tank, where it should not exceed 2 percent. Buildings should be planned so that a proper slope of the building sewer can be obtained. Where the terrain is extremely flat, however, it may be advisable to allow a slope of only 6 inches per 100 feet, or 0.5 percent (see Table 12, page 49).

The size of the pipeline to a septic tank is generally dependent upon its ability to allow objects to pass, and upon its capacity to conduct high flows for short periods, rather than upon its capacity in relation to the average flow. No building sewer serving water closets should be less than 4 inches in size. The relationship of minimum sizes to the slopes and to the number of fixture units is indicated in Table 12.

Cleanouts should be provided at the junction of the building drain and building sewer and at each change in direction of the building sewer greater than 45° They should also be provided at intervals of not more than 100 feet. That portion of the sewer line within 50 feet of any well or suction line from a well, or within 10 feet of any drinking water supply line under pressure or within 5 feet of any basement foundation should be durable, corrosion resistant, root proof, and so installed as to remain water tight. Cast iron or other high strength pipe should be required wherever the line crosses under driveways with less than 3 feet of earth cover. While no general statement can be made to cover all cases, Table 2 (page 10) should be followed in locating components of the sewage disposal system. Where sewer lines are in the vicinity of trees or dense shrubs, and are not con-

Table 12.—*Maximum number of drainage fixture units*[1] *served by building sewer of indicated size and slope*

Minimum pipe diameter, inches	Pipe slope (inch per foot)			
	1/16	1/8	1/4	1/2
4		180	216	250
5		390	480	575
6		700	840	1,000
8	1,400	1,600	1,920	2,300
10	2,500	2,900	3,500	4,200
12	3,900	4,600	5,600	6,700

[1] A drainage fixture unit is a quantity in terms of which the load producing effects of different plumbing fixtures on the plumbing system are expressed on some arbitrarily chosen scale. For example, a small lavatory is rated as 1 fixture unit; a kitchen sink, 2; a bathtub, 2; a tank operated water closet, 4; and a valve operated water closet, 6. A table of ratings from the United States of America Standards Institute National Plumbing Code is given in Appendix D, page 85.

structed of cast iron as indicated above, the joint should be made of special, root resistant construction.

Bends ahead of the septic tank should be limited to 45° or less wherever possible. If 90° bends cannot be avoided, they should be made with two 45° ells, or a long sweep quarter curve or bends.

COLLECTION SYSTEMS

At institutions where there are a number of buildings, it may be advisable to provide a system of sewers for the collection, transportation, and possibly the pumping of sewage to the septic tank. In general, the collection system should be designed for a capacity expected to be adequate for at least one decade, and preferably two. It is usually advisable to design the sewers with capacities, when running full, of not less than 10 times the average estimated flow of sewage.

Institutional sewers carrying raw or untreated sewage should be at least 6 inches in diameter and have slopes of at least 1/8 inch to the foot (1.0 percent). In very small installations, 4 inch sewers at 1/4 inch per foot (2 percent) may be used to carry raw sewage, and 4 inch sewers with slopes of 1/8 inch per foot are acceptable for carrying settled sewage. All sewers should be designed and constructed with hydraulic slopes sufficient to give mean velocities, when flowing full, of not less than 2.0 feet per second, based on Kutter's or Manning's formula using an "n" value of 0.013. Use of other practical "n" values will be permitted by the plan reviewing agency for longer pipe sections if deemed justifiable on the basis of research or field data presented.

Under exceptional conditions, if full and justifiable reasons are given,

and if special arrangements are available or will be provided for flushing, velocities as low as 1.6 feet per second may be permitted. In general, the following minimum grades should be provided:

	Percent
8 inch sewers	0.40
10 inch sewers	0.28
12 inch sewers	0.22

The use of a larger sewer to take advantage of the lesser minimum slope, when there is not enough sewage to fill the sewer nearly one-half full, is generally not advisable. The use of asbestos cement pipe or enamel lined or cement lined cast iron pipe is suggested under such conditions.

Sewer lines must be laid on straight alignment and uniform slope between manholes. Manholes should be placed on sewers at all points of change of slope or alignment, at the upper ends of all sewer lines, and otherwise at intervals not greater than 400 feet. If the topography is very uneven and frequent changes in alignment and slope are necessary, a limited number of lampholes may be substituted for manholes at such points of change. Not more than one lamphole should be placed between two successive manholes.

There must be no physical connection between a public or private potable water supply system and a sewer, sewage disposal system, or appurtenances thereto, which would render possible the passage of any sewage or polluted water into the potable water supply.

GREASE TRAPS

Premature failures of septic tank systems are sometimes due to accumulations of grease within the tanks. Sewer lines frequently clog because of grease collections. Where grease traps are used, the grease must be removed at frequent intervals. Grease traps may be used on kitchen wastelines from institutions, hotels, restaurants, schools with lunchrooms, and other places where the volume of kitchen wastes is large. After passing through the grease trap, the kitchen wastes must still be treated in the septic tank before being discharged to the disposal area. Wastes from garbage grinders should not be discharged to a grease trap. (Grease traps have been used with some degree of success for the removal of lints and fines from laundry wastes, but better results may be obtained by increasing the size of the septic tanks receiving such wastes, or by the use of rock filters to remove the lint.)

Location

Grease traps should be placed at a location that is readily accessible for cleaning, and close to the fixture discharging greasy wastes.

Construction Details

The most important considerations for design of grease traps are:

1. Capacity of the trap.

2. Facilities for insuring that both the inlet and outlet are properly trapped.

3. Ease and convenience with which the traps can be cleaned and the accumulated grease removed.

4. Inaccessibility of the traps to insects and vermin.

5. Distance between inlet and outlet, which should be sufficient to allow gravity differential separation of the grease, so that it will not escape through the outlet.

The principles are illustrated in Figure 20.

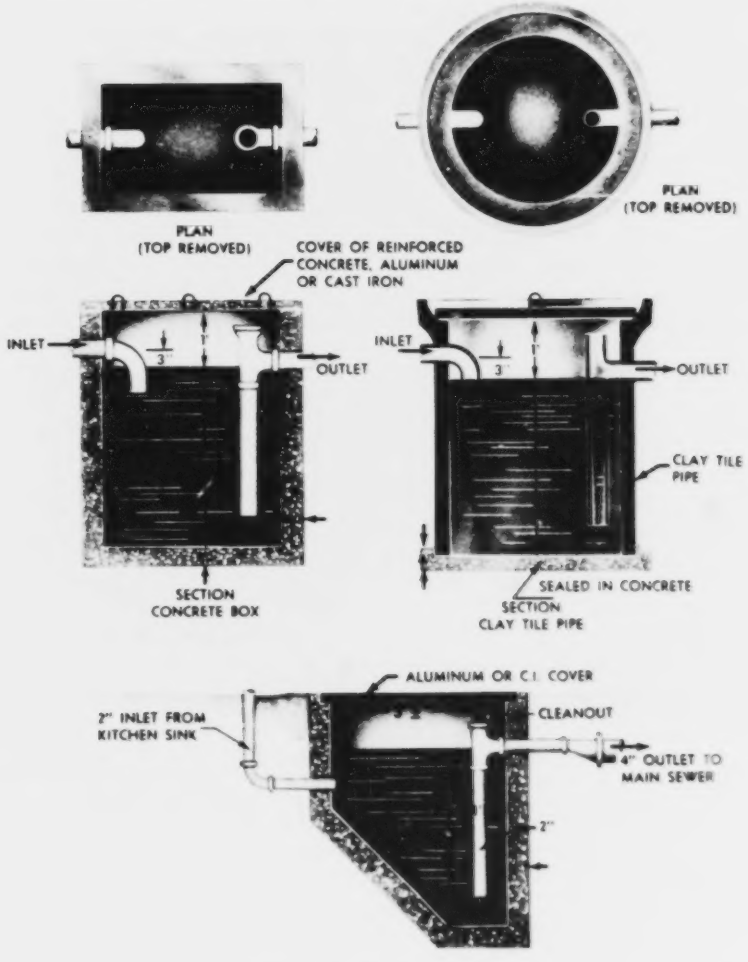


Figure 20.—Typical grease traps.

Flow control fittings should be installed on the inlet side of smaller traps to protect against overloading or sudden surges from the sink or other fixtures. Venting is not necessary in the large, outdoor traps, where siphonage of the contents can be prevented by providing outlets of liberal size. Where efficient removal of grease is very important, use has been made of an improved 2 chamber trap which has a primary (or grease separating) chamber and a secondary (or grease storage) chamber. By placing the trap as close as possible to the source of wastes, where the wastes are still hot, the separating grease at the surface may be removed by means of an adjustable weir and conveyed to the separate secondary chamber, where it accumulates, cools, and solidifies.

Capacity

Selection of size of traps should be based on verified efficiency ratings and flow capacities. The required flow capacities should be based upon the number and kind of sinks or fixtures discharging to the trap. In addition, a grease trap should be rated on its accumulated grease capacity, which is the amount of grease (in pounds) that the trap can hold before its average efficiency drops below 90 percent. It is commonly regarded that the grease retaining capacity in pounds should equal at least twice the flow rating in gallons per minute. That is to say, a trap rated at 20 g.p.m. should retain at least 90 percent of the grease discharged to it until it holds at least 40 pounds of grease. Most manufacturers of commercial traps rate their products in accordance with this procedure.

Recommended minimum flow rate capacities of traps connected to different types of fixtures is given in Table 13.

Table 13.—*Recommended ratings for commercial grease traps*

Type of fixture	Rate of flow, in g. p. m.	Grease retention capacity rating, in pounds	Recommended maximum capacity of fixture connected to trap, in gallons
Restaurant kitchen sink	15	30	37.5
Single compartment scullery sink	20	40	50.0
Double compartment scullery sink	25	50	62.5
2 single compartment sinks	25	50	62.5
2 double compartment sinks	35	70	87.5
Dishwashers for restaurants:			
Up to 30 gal. water capacity	15	30	37.5
30 to 50 gal. water capacity	25	50	62.5
50 to 100 gal. water capacity	40	80	100.0

A net capacity of 2½ gallons per person has been found large enough to hold the flow from one meal long enough to accomplish proper grease separation. The minimum allowable capacity should be about 125 gallons for small installations serving up to 50 people with proportionately larger capacities for larger populations. As with septic tanks, however, it is generally good economy to build grease traps somewhat oversize. For installations too small to justify a 125 gallon grease trap, best results can usually be obtained by applying available funds to an oversized and properly fitted septic tank.

Operation

In order to be effective, grease traps must be operated properly and cleaned regularly to prevent the escape of appreciable quantities of grease into the septic tank. The frequency of cleaning at any given installation can best be determined by experience based on observation over selected typical periods of use. Generally, cleaning should be done when 75 percent of the grease retention capacity is filled with accumulated grease.

Grease traps must be kept tightly covered to prevent odor nuisances and to exclude insects and vermin. Grease removed from the traps is disposed of by burial. (It may be used for making soap and glycerine, and for other manufacturing purposes, when economically feasible or because of shortages of such materials during wartime.)

SEPTIC TANKS FOR INSTITUTIONAL SYSTEMS

As explained in Part I, septic tanks of two compartments give better results than single compartment tanks. Although single compartment tanks are acceptable for small household installations, tanks with two or more compartments should be provided for the larger institutional systems. Tanks with more than two compartments are installed infrequently.

The compartments should be separated by walls containing ports or ell fittings at proper elevations as discussed in Part I, pages 30 and 32. In the selection of these elevations, the same general principles apply as in the design of outlet fittings. Vents for the passage of gases from one compartment to another should also be included.

In a two compartment tank, the compartment nearest the outlet is used both as a settling basin and as an observation well. The relative absence of solid material in the second compartment serves as an indication that the tank is functioning properly, although it may not serve as an index of conditions within the first compartment, and it is sometimes advisable to clean the first compartment before accumulations in the second become appreciable. In a two compartment tank, the first compartment should have a capacity of at least two to three times the capacity of the second compartment.

Whatever the number of compartments, means should be provided for gaining access to each compartment, and for measuring the depths

of sludge and scum at the outlet device as illustrated in Figure 18 (page 37). Unless tops of septic tanks are near the surface of the ground, as in Figure 15 (page 33), manholes should be provided as required to facilitate ingress and egress. A single manhole above a dividing wall may be used for gaining access to two compartments in a multicompartment tank. Manholes are also desirable over the inlet and outlet devices.

Alternate designs for manholes are shown in Figure 14 (page 32). The design selected will depend on whether or not the manhole cover must be flush with the surface, and on the anticipated traffic loadings over the area.

The effect of a multiple compartment tank can be accomplished by using two or three tanks in series. A better construction arrangement, particularly for medium or large installations, is to connect special tank sections together into a unit having single end-walls and two compartments. A unit of four precast tank sections forming two compartments is shown in Figure 21.

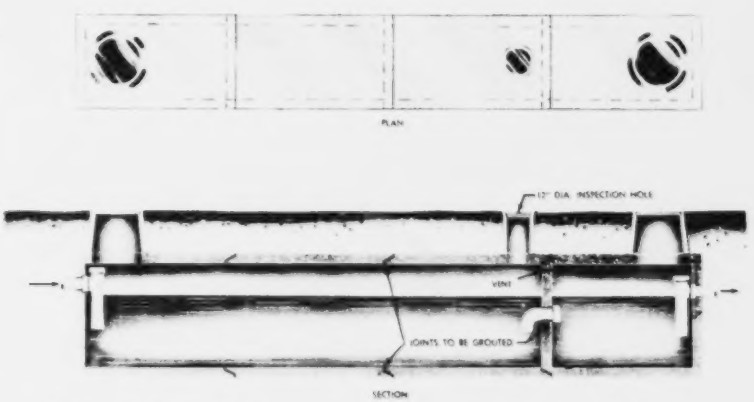


Figure 21.—Battery of four precast reinforced-concrete septic-tank sections.

Capacities

The net volume or effective capacity below the flowline of a septic tank, for flows up to 500 gallons per day, should be at least 750 gallons. For flows between 500 and 1,500 gallons per day, the capacity of the tank should be equal to at least 1½ days' sewage flow. With flows greater than 1,500 gallons per day, the minimum effective tank capacity should equal 1,125 gallons plus 75 percent of the daily sewage flow; or

$$V = 1{,}125 + 0.75Q$$

where V is the net volume of the tank in gallons and Q is the daily sewage flow in gallons. If garbage grinders are used, additional volume for extra sludge storage may be desired to minimize the frequency of cleaning.

Recommended tank capacities for flows up to 14,500 gallons per day may also be obtained from Figure 22 (below). For higher flows of up to about 100,000 gallons per day, Imhoff tanks may be more satisfactory than septic tanks for primary treatment. For flows above 100,000 gallons, still other types of sedimentation tanks may be more economical. These fall within the category of design for municipal systems, and are beyond the scope of this manual.

DOSING TANKS

When the quantity of sewage exceeds the amount that can be disposed of in about 500 lineal feet of tile, a dosing tank should be used in conjunction with the septic tank, in order to obtain proper distribu-

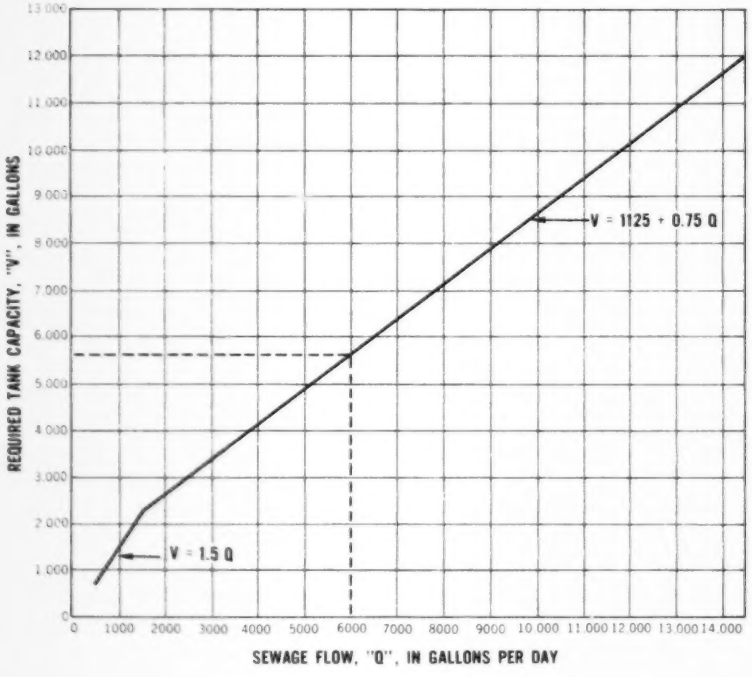


Figure 22.—Septic-tank capacities for sewage flows up to 14,500 gallons per day.

tion of sewage throughout the disposal area and give the absorption bed a chance to rest or dry out between dosings. Rest periods are always advantageous, especially when the soil is dense. The dosing tank should be equipped with an automatic siphon which discharges the tank once every 3 or 4 hours. The tank should have a capacity equal to about 60 to 75 percent of the interior capacity of the tile to be dosed at one time.

Where the total length of tile lateral exceeds 1,000 feet, the dosing tank should generally be provided with two siphons dosing alternately and each serving one-half of the tile field. The proper design of dosing devices involves hydraulic problems and head losses which must be carefully considered. Dosing siphons require operating heads ranging from about 5 feet down to a minimum of 1 or 2 feet, and repeated studies of different layouts may be necessary in order to arrive at an economical design in which available head is conserved and best use is made of existing conditions of topography. Specal siphons are manufactured for low head losses. For details and capacities, the manufacturers' bulletins should be consulted.

Special care must be taken in the installation of siphons. All dimensions and elevations should be carefully followed, and no changes should be made without prior approval by the engineer or manufacturer. Tests should be made to determine that there are no air leaks, either in the piping or bell casting, and if leaks are found, they should be repaired. Leaks may be detected by filling the dosing tank with water, to a point where the bell and piping connections are covered, and observing the water surface for rising bubbles. New siphons should be primed by filling with water when the system is first started anyway, and the tests for leakage can be made at that time.

When properly installed, automatic dosing siphons will give satisfactory service. They contain no moving parts and are more foolproof than any dosing device that depends upon moving parts for its operation. Figure 23 (page 57) shows a septic tank and dosing compartment with alternating siphons, as illustrated in suggested plans and designs developed by a State health department.

A typical layout plan or "general plan" of a system using alternating siphons is illustrated in Figure 24 (page 58).

Separate siphon compartments already equipped with siphons are made by some manufacturers. Duplex siphon compartments equipped with two siphons which operate alternately are also prefabricated.

If the head available is inadequate to permit the use of a siphon, intermittent pump operation may be used to obtain proper dosing of the field, as shown in Figure 25 (page 60). The pump discharge lines may be inter-connected to obtain flexibility and to facilitate operations when one pump is down for repairs.

SAND FILTER TRENCHES

In permeable soil, absorption trenches of the type illustrated in Figure 5 (page 12), seepage beds, or seepage pits as illustrated in Figure 10 (page 24), provide the best underground method of disposing of the effluent from a septic tank. The absorption trench is preferred, and is required in some areas where seepage pits are prohibited. In soil that is relatively impermeable, however, neither absorption trenches, seepage beds nor seepage pits are satisfactory. They become more ex-

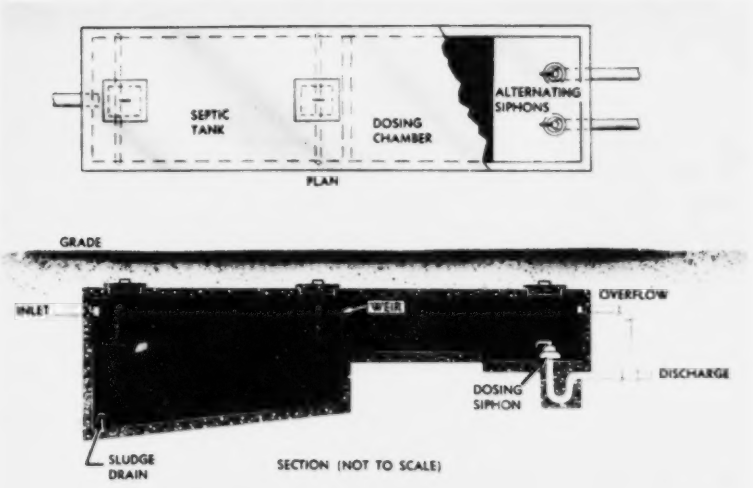


Figure 23.—Septic tank and dosing tank with alternating siphons.

pensive as the soil permeability decreases, and may not be economically feasible when the percolation time exceeds 30 or 40 minutes per inch. The exact point at which they are no longer desirable will depend largely upon the relative costs of labor and material in the locality where the disposal system is to be constructed. The decision as to whether to use absorption trenches, seepage beds or seepage pits may also depend upon the area available. Where land is at a premium, absorption trenches become less attractive. They begin to require excessive areas when the percolation time exceeds 20 minutes per inch.

When absorption trenches, seepage beds, and seepage pits are impractical for institutional or similar use, the possibility of treating the tank effluent in subsurface sand filter trenches may be considered.

The filter trenches are somewhat similar to absorption trenches, the major difference being that the filter trenches are deeper, generally somewhat wider, contain an intermediate layer of sand as filtering material, and are provided with underdrains for carrying off the filtered sewage. The tank effluent is not absorbed, except to a limited extent. It is simply filtered and must be disposed of when it leaves the trench.

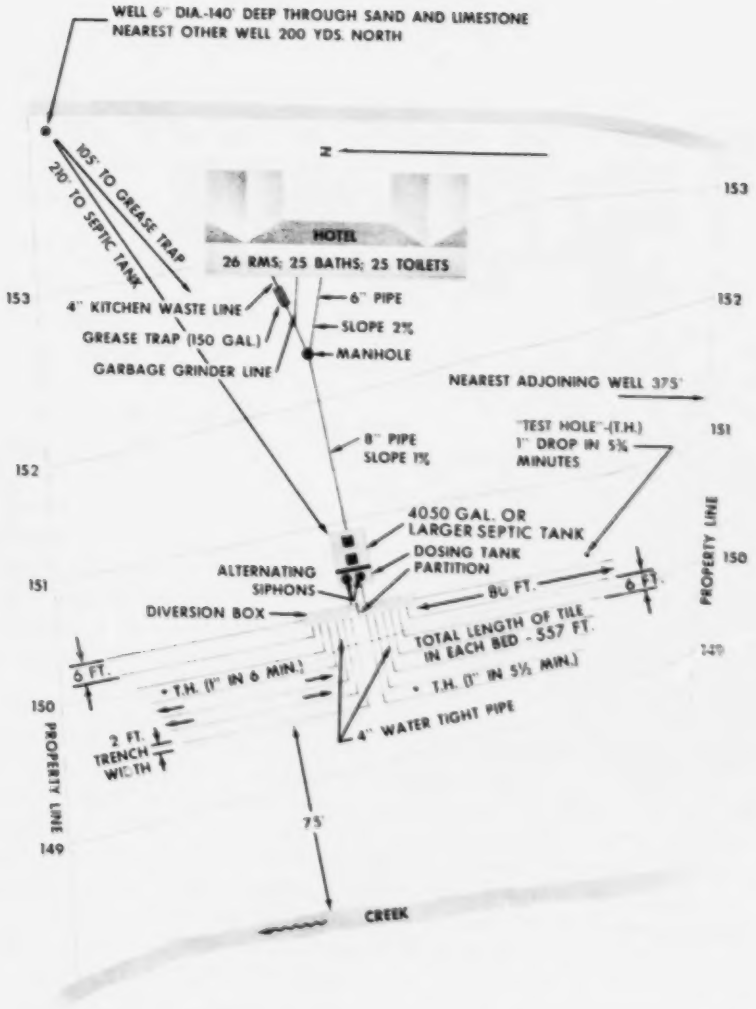


Figure 24.—Typical layout plan of a subsurface sewage-disposal system.

DESIGN DATA FOR DISPOSAL ILLUSTRATED IN FIGURE 24

Hotel

26 rooms total

20 rooms with private baths × 2 persons per room × 60 gal. per person per day = 2,400 gal. per day

6 rooms with connecting baths × 2 persons per room × 50 gal. per person per day = 600 gal. per day

5 daytime employees × 25 gal. per person per day = 125 gal. per day

2 night employees × 25 gal. per person per day = 50 gal. per day

Kitchen wastes: 60 persons × 3 meals per day × 4 gal. per meal = 720 gal. per day

Total daily sewage flow = 3,895 gal. per day

Required septic tank capacity (from Fig. 22) = 4,046 gal.

(In this case, consideration should be given to using a 5,000 gal. capacity tank which will require less frequent cleaning.)

Required grease trap capacity 60 persons × 2½ gal. = 150 gal.

Percolation test: 6 min. per inch drop.

Allowable rate of sewage application (from Fig. 19) = 2.1 gal. per sq. ft. per day

Trench area required for normal wastes = $\frac{3895}{2.1}$ = 1,855 sq. ft.

Plus 20% additional for wastes from garbage grinder 371 sq. ft.

Total trench area required = 2,226 sq. ft.

Desired trench width = 24 inches (2.0 ft.)

Total trench length = $\frac{2226}{2}$ = 1,113 ft.

As stated in the section on Dosing Tanks, where the length of trench exceeds 1,000 feet a dosing tank should be used with alternating siphons, each serving one half of the absorption field.

$\frac{\text{Total trench length}}{\text{Number of separate absorption fields}} = \frac{1113}{2} = 557$ Lineal ft. of trench per field.

80 ft. lengths can best be worked into available disposal area with room for future additions if needed.

$\frac{557}{80}$ = 7 lines of (4") laterals required for each field.

Preferred dosing tank capacity = 75 percent of interior capacity of tile to be dosed at one time.

4" tile = 3.14 × 2^2 × 12 = 151 cu. in. per ft.

$\frac{151 \text{ cu. in. ft.} \times 0.75}{231 \text{ cu. in. gal.}}$ = 0.49 gal. ft. required dosing tank capacity (say 0.5)

Thus the capacity of the dosing tank should be 0.5 gal. ft. × 7 × 80 ft. = 280 gallons.

For this reason, filter trenches are properly regarded as a means of sewage *treatment*, and not sewage disposal. They accomplish a high degree of purification, however, and the sewage effluent coming from a filter trench that is properly designed can sometimes be disposed of without further treatment, by discharging into ditches, small streams, or dry streambeds. If the receiving stream contributes to a source of water supply, shellfish growing area, or recreational area, chlorination should be required as hereinafter explained. In some jurisdictions, chlorination is required for all effluents from sand filters.

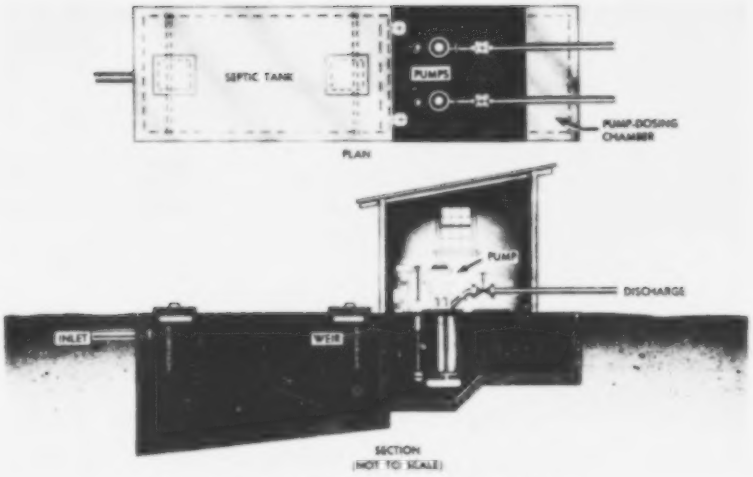


Figure 25.—Septic tank and pump-dosing chamber.

Approval should be obtained from the State or local health department before alter trenches are installed. This method of sewage treatment becomes less economical and less desirable as the quantity of sewage and the required area increase. Subsurface sand filters may be needed for larger installations.

Construction Features

Typical details of an underdrained sand filter trench are shown in Figure 26 (page 61). For all year service, filter trenches should be designed for filtration rates as given in Table 14.

Table 14.—*Loading rates for subsurface filters*

Type of service	Area Requirements	
	Gallons per acre per day	Gallons per square feet per day
Without garbage grinder or automatic washer	50,000	1.15
With garbage grinder	41,500	0.95
With automatic washing machine	50,000	1.15
With both garbage grinder and automatic washer	41,500	0.95

The filtering material should be clean, coarse sand, all passing a screen having four meshes to the inch.

The sand should have an effective size between 0.25 and 0.6 mm

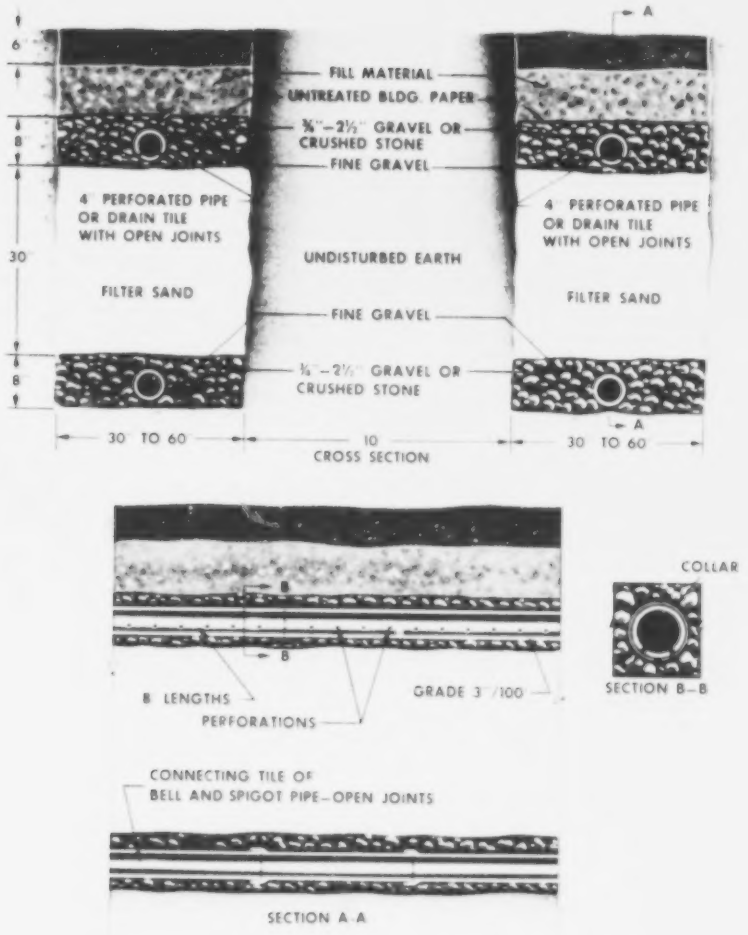


Figure 26.—Underdrained sand-filter trench.

and preferably 0.4 to 0.6 mm. The uniformity coefficient should be less than 4.0.

Fine sand will lead to premature clogging and a need for replacement. The sand should be not less than 2 feet deep.

The distributors and underdrain should be surrounded by coarse screened gravel or crushed stone. All of the gravel or stone should pass a $2\frac{1}{2}$ inch screen and should be retained on a $\frac{3}{4}$ inch screen. Fine gravel, down to $\frac{1}{4}$ inch, may be used above and around the coarse material, both at the distributors and at the underdrains.

The slope of the distributors should be about 0.5 percent where

dosing tanks are not used, and the slope of the underdrains about 0.5 to 1.0 percent. It is essential that the sand be thoroughly settled by flooding or other means before the distributors are placed at the final grade. The distributor and underdrains may be of agricultural tile or, bell and spigot pipe, or perforated pipe.

SUBSURFACE SAND FILTERS

As indicated previously, filter trenches are not economical for large installations. Subsurface sand filters are cheaper. They require less area, and will do the job just as well as filter trenches. They require more care in design and construction, but this is more than offset by savings in cost. As a rough guide, filter trenches are impracticable when the amount of sewage (and consequently the filter area or the length of tile distributors) is enough to require the use of dosing siphons. Subsurface sand filters are generally indicated when dosing siphons are needed in conjunction with artificial filtration.

The principles of design of subsurface sand filters are similar to the fundamentals involved in the layout of filter trenches. Both types of installations have distributors and underdrains, with filter sand between. The essential difference in the two is that filter trenches are smaller and the filter material is laid in trenches, as implied in the name. When two or more trenches are used, natural earth is permitted to remain between them. For subsurface sand filters, on the other hand, the entire filtration area is filled in artificially. A typical plan and section of a subsurface sand filter are illustrated in Figure 27 (page 63).

Construction Features

The sand in a subsurface filter should be of a quality at least equal to that specified for a filter trench, with an effective size preferably between 0.4 and 0.6 mm, and never less than 0.25 mm, and with a uniformity coefficient less than 4.0. The gravel or crushed stone should likewise be equal to the quality previously specified. The same depth of sand is used, and the required filter area is the same as given in Table 14, with one exception: Where filters are constructed solely for seasonal use and have long rest periods over the greater part of the year, they may be expected to work satisfactorily at rates as high as twice those given in Table 14, provided that the sand has an effective size no smaller than 0.4 mm.

Dosing tanks should be provided where the total filter area exceeds 1,800 square feet and where the distributors exceed 300 lineal feet. The size of the dose, or the net capacity of the dosing tank, should be 60 to 75 percent of the volume of the distributors dosed at one time. When an installation has over 1,000 feet of distributors, best results can be obtained by constructing the filter in two or more sections, dosed separately by alternating siphons.

The distributors and underdrains may be of agricultural tile, bell

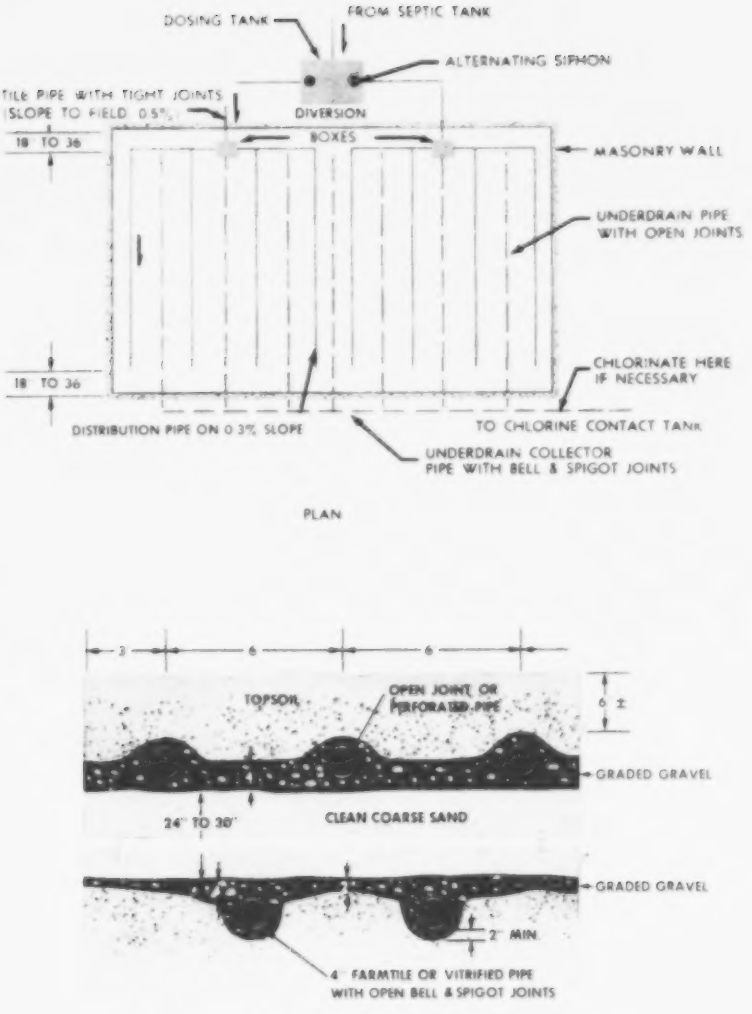


Figure 27.—Typical plan and section of a subsurface sand filter.

and spigot pipe; or perforated pipe. Special joints of the precast, sleeve coupling, and taper coupling types are available which insure alignment of the pipe lengths. In any event, the distributors should be laid accurately to grade *after* the filter sand has been thoroughly settled by flooding or other means. It may be necessary to surround the filter bed with a masonry wall to retain the filter bed.

Where dosing tanks are used, the distributors should be laid to 0.3 percent grade; otherwise, they are laid to a grade of about 0.5 percent.

SUPERFICIAL SAND FILTERS

In some areas, the ground water table is too near the surface to permit construction or successful operation of any subsurface method of sewage disposal. The construction of buildings and sewage disposal systems should generally be avoided in such places. Sometimes, however, the elevation of the water table may be found to fluctuate over a wide range unexpectedly. Through floods or other hydrologic conditions, areas which, for decades, may have experienced a water table appreciably below the ground surface may suddenly be faced with a condition wherein the ground water approaches or even covers the surface. Sometimes such occurrences are brought about artificially, as by the construction of dams or dikes, and the conditions may be likely to remain relatively permanent.

As previously explained, impervious soil may also preclude subsurface methods of disposal, and the occurrence of solid rock at or just below the surface of the ground may make subsurface treatment methods uneconomical.

In these events, it may be necessary to forego completely the construction or renovation of subsurface methods of sewage treatment and disposal. The circumstances may require treatment and disposal by superficial means above the surface of the ground. This frequently necessitates pumping, but can be accomplished in superficial sand filters constructed as shown in Figure 28 (page 65), except that the ends and sides must be surrounded by a masonry wall or earth dike for retaining the filter bed. The filters may be completely above the ground or only partly above the surface, depending primarily upon the depth to ground water or the depth to solid rock, as the case may be.

From the standpoint of operation, sewage filters do not have to be covered, but in built-up areas a shallow earth cover of about 6 inches is recommended, to prevent freezing in cold weather and to prevent emanation of odors and other nuisances from the septic sewage in warm weather. While open filters are accessible for cleaning and can be operated at higher rates than those covered with earth, they ordinarily require daily attention, and are not usually advisable for private installations where septic tanks are used. They are more suitable for municipalities and large institutions where sewage plant operators are employed. In such cases, the filters generally follow a conventional primary settling tank or secondary treatment and secondary settling tanks, and the method of distributing sewage onto open filters is different from that indicated for covered filters. Figure 28 (page 65) illustrates a typical installation of open filter beds.

Open filters are operated intermittently and, thus, are known as intermittent sand filters. They should always be divided into two or more units. Sand specifications and depths are the same as for subsurface sand filters. Loading rates are influenced by temperature, effective size and uniformity coefficient of the filtering medium, and the charac-

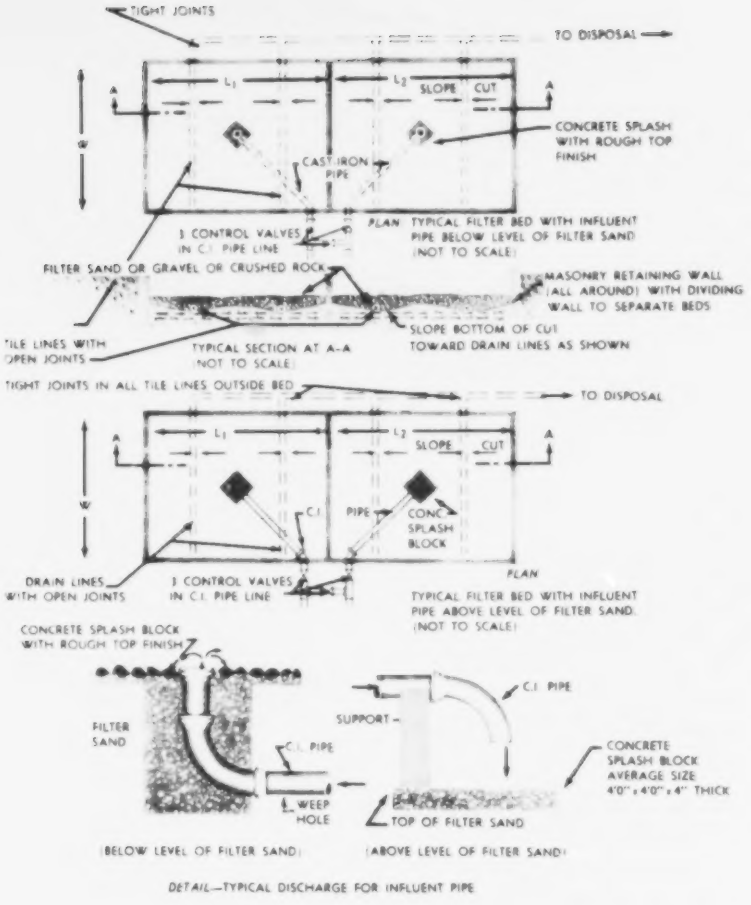

TIGHT JOINTS
TO DISPOSAL
SLOPE CUT
CONCRETE SPLASH WITH ROUGH TOP FINISH
CAST IRON PIPE
3 CONTROL VALVES IN C.I. PIPE LINE
PLAN TYPICAL FILTER BED WITH INFLUENT PIPE BELOW LEVEL OF FILTER SAND (NOT TO SCALE)
FILTER SAND OR GRAVEL OR CRUSHED ROCK
MASONRY RETAINING WALL (ALL AROUND) WITH DIVIDING WALL TO SEPARATE BEDS
SLOPE BOTTOM OF CUT TOWARD DRAIN LINES AS SHOWN
TILE LINES WITH OPEN JOINTS
TYPICAL SECTION AT A-A (NOT TO SCALE)
TIGHT JOINTS IN ALL TILE LINES OUTSIDE BED
TO DISPOSAL
SLOPE CUT
C.I. PIPE
CONC. SPLASH BLOCK
DRAIN LINES WITH OPEN JOINTS
3 CONTROL VALVES IN C.I. PIPE LINE
PLAN
TYPICAL FILTER BED WITH INFLUENT PIPE ABOVE LEVEL OF FILTER SAND. (NOT TO SCALE)
CONCRETE SPLASH BLOCK WITH ROUGH TOP FINISH
FILTER SAND
C.I. PIPE
SUPPORT
C.I. PIPE
CONCRETE SPLASH BLOCK AVERAGE SIZE 4'0" x 4'0" x 4" THICK
WEEP HOLE
TOP OF FILTER SAND
(BELOW LEVEL OF FILTER SAND)
(ABOVE LEVEL OF FILTER SAND)
DETAIL—TYPICAL DISCHARGE FOR INFLUENT PIPE

Figure 28.—Open-filter-bed layout.

teristics of the sewage to be treated. The last depends largely upon the degree of pretreatment received by the influent to the filter, but, since this manual is concerned only with septic tank systems, pretreatment may be ruled out of consideration here. Table 15 gives recommended maximum loading rates for the effluents from septic tanks which do not receive wastes from garbage grinders or automatic washing machines.

Table 15.—*Recommended loading rates of septic tank effluents on open sand filters with uniformity coefficients not over 4.0*

[Gallons per acre per day [1]]

Region	Effective Size of Sand				
	0.2 mm.	0.3 mm.	0.4 mm.	0.5 mm.	0.6 mm.
Southern U. S.	100,000	130,000	160,000	180,000	200,000
Northern U. S.	80,000	100,000	120,000	140,000	160,000

[1] Multiply rates by 0.83 if garbage grinders are used.

In addition to dosing by siphons or pumps, some open filters are dosed by means of hand operated gates or valves. In some places, it has been customary to dose about once a day. Other plants operate with as many as 4 doses per filter per day, but some dose at long and irregular intervals of several days. With fine sands, filtration efficiencies are increased by loading twice daily. With coarse sand (0.45 mm and up), efficiencies are increased by loading more frequently than twice a day, but multiple loadings present a problem in obtaining adequate coverage of the bed. Spray nozzles and rotary distributors have been used with reasonable success as dosing devices in some small installations, but it has been found necessary to cover the surface of the sand with several inches of pea gravel in order to prevent disturbance of the surface sand.

Dosing tanks should have capacities that will provide for flooding the beds to depths of 2 to 4 inches. Discharge from the dosing tanks should at least equal the flow of the raw sewage.

Since various States have different requirements or policies regarding open filter installations, the State or local health department should always be consulted before filters of this type are designed.

CHLORINATION

Filter trenches and artificial sand filters that are properly designed and operated will produce an effluent that is clear and sparkling, and the filtration will remove a high percentage of the bacteria contained in the sewage. Some of the remaining bacteria may still be capable of producing disease, however, and the sewage effluent must be disinfected if it is discharged to a ditch that is accessible to humans, or to a stream that contributes to a nearby source of water supply used for drinking, growing of shellfish, or swimming. Chlorine is the disinfectant most commonly used.

Present custom is to apply chlorine in the amount necessary to obtain a chlorine residual of 0.5 to 1.0 ppm after thorough mixing and 15

minutes contact at peak flows. On an average, this requires a chlorine dosage in the neighborhood of 6 ppm for sand filter effluents. This is equivalent to ½ pound of available chlorine for every 10,000 gallons of sewage, or less than 1 ounce per 1,000 gallons. Most States require a chlorine contact chamber large enough to retain the sewage for at least 15 minutes. A typical design is illustrated in Figure 29 (page 68).

Chlorine may be obtained in steel cylinders in which the gas is compressed to a liquid state. It may also be obtained from sodium hypochlorite or calcium hypochlorite.

Sodium hypochlorite is obtainable only as a solution. Upon drying, it decomposes. Solutions of hypochlorite are obtainable in strengths ranging from 1 percent to 15 percent of available chlorine. This material is corrosive to ordinary metals and should be handled in glass, stoneware crocks or plastic containers.

Calcium hypochlorite is obtainable only in a dry form, of which there are two principal types. *Hypochlorite of lime* (or "bleaching powder") contains about 35 percent of available chlorine when manufactured, and *high-test hypochlorite* contains about 70 percent of available chlorine.

The ordinary hypochlorite of lime is really a mixture of compounds which may be largely a calcium oxychloride. It is not stable, and may lose a large percentage of its chlorine content if stored for long periods. When made into a water solution, it also has the undesirable characteristic of forming a scale of calcium carbonate which tends to clog the feeding apparatus. It is cheaper than high-test hypochlorite, however, and it can be used satisfactorily with certain types of feeding equipment, if large solution tanks are employed and if proper precautions are taken in the preparation and utilization of the solution. The undissolved portion must be allowed to settle out of the solution, and only the clear, supernatant liquid fed through the feeding apparatus.

High-test hypochlorite is a true calcium hypochlorite. It is more stable and more convenient to handle than ordinary hypochlorite of lime. It is available under several trade names, familiar to sanitary engineers and sanitarians. When made up with soft water in solutions containing 1 to 2 percent of available chlorine, calcium hypochlorite does not give much trouble with calcium carbonate deposits, but precaution should still be taken to feed only the clear, supernatant portion of the solution through the feeding equipment. When hard water is used to make up the solution, the addition of a small quantity of sodium hexametaphosphate will help prevent deposits.

The decision between sodium hypochlorite or calcium hypochlorite should depend upon the relative costs of the two materials in the locality of the job. Information as to their costs can usually be obtained from the suppliers of the hypochlorinators.

The decision as to whether to apply chlorine as a gas or in liquid form as a hypochlorite is sometimes dependent on the availability of

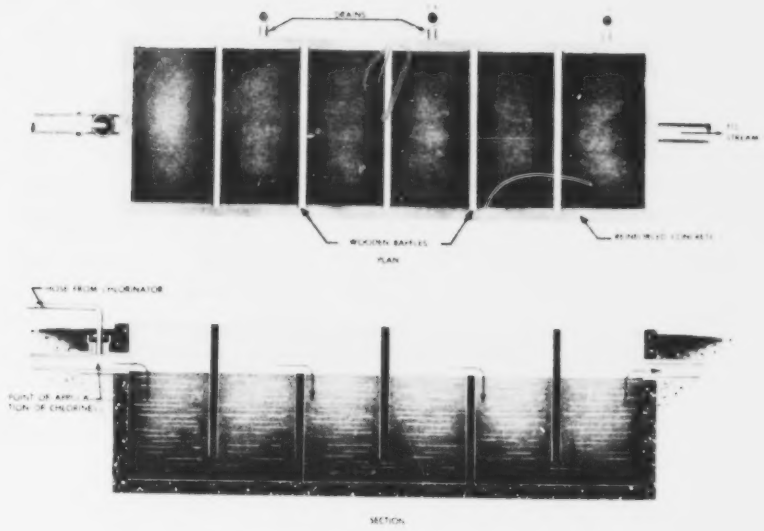


Figure 29.—Chlorine-contact chamber.

power. Most manufactured hypochlorinators require either electric current or clean water under pressure for their operation. In some remote places, these are not available. In such cases, hypochlorinators using chlorine in cylinders can be operated without any outside power source.

Usually, however, power is available and the decision as to whether to use hypochlorite or chlorine gas is dependent upon their relative cost. Gas is the cheaper of the two, but equipment for controlling it is much more expensive than simple hypochlorite feeders.

In general, hypochlorite is preferred when the amount of chlorine required is less than 2 or 3 pounds per day. In other words, hypochlorite would normally be used for disinfecting the effluent from a sand sewage filter for sewage flows up to about 50,000 gallons per day. For chlorinating a septic tank effluent, the sewage flow limit for hypochlorinators would be about 10,000 gallons per day. Beyond these quantities, savings in the cost of the chlorine gas will usually offset the more expensive original investment in equipment.

Several satisfactory types of hypochlorinators are available. Various types of chlorinators are also made. Both kinds of apparatus are being gradually improved. Both require routine maintenance. Therefore, in choosing the make of apparatus to be purchased, the first consideration should be that of service. It is practically always advisable to purchase a chlorinator from a manufacturer who has a fulltime serviceman traveling through the area where it is to be used. Jobbers and agents handling chlorinators are seldom qualified to furnish the best technical assistance, and are usually unable to render the prompt service that is necessary when a chlorinator gets out of order.

Wherever chlorination is necessary, daily tests should be made to determine the amount of chlorine residual after the requisite contact period. Many health departments require monthly reports giving the results of the tests.

The test is simple. It is usually made by adding a small amount of standard orthotolidine solution to a sample of the effluent and comparing the color developed with color standards which may be obtained with the solution from most laboratory supply houses. If the color of the sample changes to an orange-yellow hue, it indicates that chlorine is being applied in a proper amount.

Appendices

Introduction To Appendices

Since conditions vary in different parts of the country, practices that are suitable in one section may not be acceptable in another. Thus, it would not be feasible to suggest one set of standards that should be followed in all circumstances. In a sense, this may be considered fortunate, as, to paraphrase Sedgwick, "Standards are devices to keep the lazy mind from thinking." In public health work there can be no substitute for the use of judgment or discretion, more aptly termed by Phelps as an exercise of "the principle of expediency."

Just as no individual design of a sewage disposal system is applicable for universal adoption because of varying local conditions, so also no single ordinance or code would be universally applicable. Though some States and many local health departments have laws or regulations governing the installation of individual sewage disposal systems, there is still a growing need for reasonable regulations which will protect the public from unsound practices leading to health hazards. The suggested ordinance governing individual sewage disposal systems presented in these appendices may be useful as a guide in the development of new, or the revision of existing, regulations on this subject.

The purpose of these appendices, therefore, is to discuss additional practices which have been found successful in some parts of the country, although their application may be necessarily limited in other parts, and also to present some additional information considered useful to workers in this field.

Appendix A

Soil Absorption Capacity

GUIDE FOR ESTIMATING SOIL ABSORPTION POTENTIAL

A percolation test is the only known means for obtaining a quantitative appraisal of soil absorption capacity. However, observation and evaluation of soil characteristics provide useful clues to the relative capacity of a soil to absorb liquid. Most suitable and unsuitable soils can be identified without additional testing. When determined and evaluated by trained or experienced soil scientists or soil engineers, soil characteristics may permit further categorizing of suitable soils. This has been done for some areas of the country and described in the soils reports mentioned below.

Soil Maps.—The capacity of a soil to absorb and transmit water is an important problem in agriculture, particularly in relation to irrigation, drainage, and other land management practices. Through studies in these fields, a variety of aids have been developed for judging the absorption of water transmission properties of soils, which could be helpful in the sewage field. Considerable information has been accumulated by agricultural authorities on the relative absorption capacities of specific soils in many areas of the United States. Much of this information is included in Soil Survey Reports and Maps published by the United States Department of Agriculture in cooperation with the various State agricultural colleges. The general suitability of specific soils for effluent disposal may often be interpreted from these reports and maps.

Clues to Absorption Capacity.—Considerable information about relative absorption capacities of soils may also be obtained by a close visual inspection of the soil. The value of such an inspection depends upon some knowledge of the pertinent soil properties. The main properties indicative of absorption capacity are soil texture, structure, color, depth or thickness of permeable strata, and swelling characteristics.

Texture.—Soil texture, the relative proportion of sand, silt, and clay, is the most common clue to water absorption capacity. The size and distribution of particles govern the size and distribution of pores which, in turn, govern the absorption capacity. The larger the soil particles, the larger are the pores and the faster is the rate of absorption.

Texture can best be judged by the feel. The lighter or sandier soils

have a gritty feel when rubbed between the thumb and forefinger; silty type soils have a "floury" feel and, when wetted have no cohesion; heavier, clay type soils are dense and hard when dry, and have a slick greasy feel when wetted.

The use of texture as a clue to absorption qualities has its limitations; it is primarily reliable in the sandier soils. In the heavier type soils, including sandy soils containing appreciable amounts of silt or clay, one must look for additional clues, such as structure and soil color, as indicators of absorption capacity.

Structure.—Soil structure is characterized by the aggregation or grouping together of textural particles, forming secondary particles of larger size. Such secondary particles then tend to govern the size and distribution of pores and, in turn, the absorption properties. Structure can easily be recognized by the manner in which a clod or lump breaks apart. If a soil has structure, a clod will break with very little force, along well defined cleavage planes, into uniformly sized and shaped units. If a soil has no structure, a clod will require more force to break apart and will do so along irregular surfaces, with no uniformity in size and shape of particles.

In general, there are four fundamental structure types, named according to the shape of the aggregate particles: platy, prism-like, block-like, and spheroidal. A soil without structure is generally referred to as massive. Spheroidal structure tends to provide the most favorable absorption properties, and platy structure, the least. Although other factors, such as size and stability of aggregates to water, also influence the absorption capacity, recognition of the type of structure is probably sufficient for a general appraisal.

Color.—One of the most important practical clues to water absorption is soil color. Most soils contain some iron compounds. This iron, like iron in a tool or piece of machinery, if alternately exposed to air and to water, oxidizes and takes on a reddish-brown to yellow color. Thus, if a soil has uniform reddish-brown to yellow oxidized color, it indicates that there has been free alternate movement of air and water in and through the soil. Such a soil has desirable absorption characteristics. At the other extreme are soils of a dull gray or mottled coloring, indicating lack of oxidizing conditions or very restricted movement of air and water. These soils have poor absorption characteristics.

Depth or Thickness of Permeable Strata.—The quantity of water that may be absorbed is proportional to the thickness or volume of the absorbent stratum, when all other conditions are alike. In a soil having a foot or more of permeable material above tight clay, absorption capacity is far greater than that of the same kind of material lying within 3 inches of tight clay. When examining soils or studying soil descriptions, the depth and thickness, therefore, are important criteria of absorption capacity.

Swelling Characteristics.—Most, but not all, clays swell upon the

addition of moisture. There are many clays (in the tropics, in particular) that do not swell appreciably. There are also some soils in the United States which do not swell noticeably. On the other hand, some soils have a very high percentage of swelling, and these in particular must be suspect. Relative swelling of different soils is indicated by relative shrinkage when dry, as shown by the numbers and sizes of cracks that form. Those that shrink appreciably when dry are soils that may give trouble in a tile field when they are wet.

Information obtained through inspection or from soil maps and reports can be of particular value in preliminary appraisal of soils for sewage disposal. For instance, in many cases, unsuitable soils may be immediately ruled out on the basis of such information; in other cases, selection of the best of several sites may be made on the basis of the inspection. Absorption capacity information obtained in this manner is relative. For quantitative information upon which to base specific design, we still must depend on some direct measurement, such as a water absorption rate as measured by a percolation test.

EVAPOTRANSPIRATION

In tight clay soi's, where absorption is very limited, plant transpiration has been employed with some degree of success in aiding in the disposal of sewage effluent. By placing the tile lines near the top of the trench, where they are not likely to become clogged with roots, or by laying the lines practically at ground surface and covering with suitable fill material, use may be made of the action of trees, shrubs, and grasses in the absorption and subsequent release to the atmosphere of appreciable quantities of moisture, through the process of evapotranspiration.

Climate is important. Evapotranspiration increases wth decreasng humidity and increasing temperature and air turbulence. Length of day and amount of sunshine are further influencing factors. Consequently, evapotranspiration should be of most benefit to soil absorption systems in the southern portion of the country, where the growing season is longest. In the extreme North, where the growing season extends only from May to September, evapotranspiration would be of minimum value, but may be useful in summer resort areas.

Because of these variations, and equally great variations in the types of plants grown in different parts of the country, as well as the differing transpiration rates in different plants, it would be hazardous to generalize in making specific suggestions on design criteria for systems dependent on evapotranspiration for successful operation.

CURTAIN DRAINS FOR ABSORPTION TRENCH SYSTEMS

Even though proper precautions are taken to ascertain the maximum ground water table before the absorption trench method of sewage effluent disposal is approved for a given area, instances occur where the height of a water table rises above that indicated by past performances and observations. This may lead to failure of the disposal system.

It is sometimes possible to rehabilitate such a system by constructing around the disposal area a curtain drain designed to intercept the superficial ground water and carry it away from the area. If the absorption field is on sloping ground, a single drain at the upper end of the area may be sufficient. Where open curtain drains are not feasible, rock-filled trenches above or around the disposal area may sometimes be used. In either case, it is necessary to have a suitable outlet for the ground water that is intercepted.

PERCOLATION TEST HOLES

When making percolation tests in some types of soil, it has been found that the side walls of test holes have a tendency to cave in or slough off, and settle to the bottom. The condition is most likely to occur where the earth is initially dry and overnight soaking is necessary. The caving can be prevented, and more accurate results obtained, by placing in the test hole a wire cylinder surrounded by gravel of the same size that is used in the tile field.

OTHER PERCOLATION TESTS

A Soil Percolation Test for Determining the Capacity of Soils for Absorption Sewage Effluents, by John E. Kiker, Jr.[1]

1. Dig a hole about 1 foot square to the depth at which it is proposed to lay the tile drain.

2. Fill the hole with water and allow the water to seep away. When the water level falls to within 6 or 8 inches of the bottom of the hole, observe the rate at which the water level drops.

3. Continue these observations until the soil is saturated and the water seeps away at a constant rate. (Keep adding water until the rate becomes constant.)

4. Compute the time required for the water to drop 1 inch after the soil becomes saturated. This is the standard percolation time, t.

A Percolation Test for Determining the Capacity of Soils for Absorption Sewage Effluents, by Harvey F. Ludwig, Gordon W. Ludwig, and John Stewart.

While the previously cited percolation tests include procedures generally familiar to workers in this field, the method proposed by Ludwig et al., includes an additional step. The field data are further analyzed graphically to obtain the percolation rate under saturated soil conditions. The mathematical evaluation is based on the premise that the ratio, time in minutes for the water level to drop 1 inch, is constantly increasing during the progress of the test, but at a rate of increase which is constantly decreasing. This hyperbolic relationship is utilized to determine the maximum ratio $\frac{minutes}{inch}$ which is the saturated

[1] Reprinted from Subsurface Sewage Disposal, by John E. Kiker, Jr., Bulletin No. 23, Florida Engineering and Industrial Experiment Station, 1948.

condition under which water would seep away at a constant rate. A discussion of this method with illustrations and an example is found in the following articles: Improved Soil Percolation Test, Harvey F. Ludwig and Gordon W. Ludwig, *Water and Sewage Works Journal*, vol. 96, no. 5, May 1949, p. 192; Equilibrium Percolation Test for Estimating Soil Leaching Capacity, Harvey F. Ludwig and John Stewart, *Modern Sanitation*, vol. 4, no. 10, Oct. 1952.

Appendix B

Suggested Ordinance

The following is suggested for consideration in drafting an ordinance for local application to permit the exercise of appropriate legal controls over individual sewage disposal systems.[1] Persons utilizing this draft as a guide are urged to familiarize themselves with the applicable legal requirements governing adoption of ordinances of this kind in their locality.

AN ORDINANCE GOVERNING INDIVIDUAL SEWAGE DISPOSAL SYSTEMS

An ordinance defining and regulating individual sewage disposal systems; requiring minimum standards governing the design, construction, and installation of septic tank-soil absorption systems, privies, and chemical-type toilets; authorizing the issuance of permits, and providing for penalties for violations.

Section I—Definitions

For the purposes of this ordinance, the following words and phrases shall have the meanings ascribed to them in this section.

1.1.1 *Health officer* shall mean the legally designated health authority of the (name of political subdivision) or his authorized representative.

1.1.2 *Individual sewage disposal system* shall mean a sewage disposal system, other than a public or community system, which receives either human excreta or liquid waste, or both, from one premises. Included within the scope of this definition are septic tank-soil absorption systems, privies, and chemical type toilets, and such other types as may be prescribed in regulations by the health officer.

1.1.3 *Permit* shall mean a written permit issued by the health officer, permitting the construction of an individual sewage disposal system under this ordinance.

1.1.4 *Person* shall mean any institution, public or private corporation, individual, partnership, or other entity.

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[1] Reference should also be made to *Recommended State Legislation and Regulations: Urban Water Supply and Sewerage Systems Act and Regulations, Water Well Construction and Pump Installation Act and Regulations, Individual Sewerage Disposal Systems Act and Regulations,* U.S.D.H.E.W., Public Health Service, July 1965.

Section II—Requirements for Individual Sewage Disposal Systems

2.1 The health officer of (name of political subdivision), in order to protect the health and safety of the people of (name of political subdivision) and of the general public, is authorized and directed, after public hearing, to promulgate and amend, from time to time, regulations establishing minimum standards governing the design, construction, installation, and operation of individual sewage disposal systems. Such regulations shall establish such minimum standards as, in the judgment of the health officer, will insure that the wastes discharged to various individual sewage disposal systems:

1. Do not contaminate any drinking water supply.
2. Are not accessible to insects, rodents, or other possible carriers of disease which may come into contact with food or drinking water.
3. Do not pollute or contaminate the waters of any bathing beach, shellfish breeding grounds,[2] or stream used for public or domestic water supply purposes or for recreational purposes.
4. Are not a health hazard by being accessible to children.
5. Do not give rise to a nuisance due to odor or unsightly appearance.
6. Will not violate any other laws or regulations governing water pollution or sewage disposal.

2.2 The health officer is authorized to promulgate such additional regulations as are necessary in his judgment to carry out the provisions of this ordinance.

Section III—Permits

3.1 It shall be unlawful for any person to construct, alter, or extend individual sewage disposal systems within the (name of political subdivision) unless he holds a valid permit [3] issued by the health officer in the name of such person for the specific construction, alteration, or extension proposed.

3.2 All applications for permits shall be made to the health officer, who shall issue a permit upon compliance by the applicant with provisions of this ordinance and any regulations adopted hereunder.

3.3 The health officer may refuse to grant a permit for the construction of an individual sewage disposal system where public or community sewerage systems are reasonably available.

3.4 Applications for permits shall be in writing, shall be signed by the applicant, and shall include the following:

3.4.1 Name and address of the applicant.

Lot and block number of property on which construction, alteration, or extension is proposed.

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[2] Optional with locality.

[3] The permit issued by the Health Officer is in addition to the building permit usually required and should be obtained prior to construction, alteration, and extension of the residence or facility to be served.

3.4.2 Complete plan of the proposed disposal facility, with substantiating data, if necessary, attesting to its compliance with the minimum standards of the health officer.

3.4.3 Such further information as may be required by the health officer to substantiate that the proposed construction, alteration, or extension complies with regulations promulgated by the health officer.

3.5 A complete plan for the purpose of obtaining a permit to be issued by the health officer shall include:

3.5.1 The number, location, and size of all sewage disposal facilities to be constructed, altered, or extended.

3.5.2 The location of water supplies, water supply piping, existing sewage disposal facilities, buildings or dwellings, and adjacent lot lines.

3.5.3 Plans of the proposed sewage disposal facilities to be constructed, altered, or extended.

3.6 Any person whose application for a permit under this ordinance has been denied may request and shall be granted a hearing on the matter before the health officer within 30 days after receipt of the request.

Section IV—Inspections

4.1 The health officer is hereby authorized and directed to make such inspections as are necessary to determine satisfactory compliance with this ordinance and regulations promulgated hereunder.

4.2 It shall be the duty of the owner or occupant of a property to give the health officer free access to the property at reasonable times for the purpose of making such inspections as are necessary to determine compliance with the requirements of this ordinance and regulations promulgated hereunder.

Section V—Penalties

5.1 Any person who violates any provision of this ordinance, or any provision of any regulation adopted by the health officer pursuant to authority granted by this ordinance, shall, upon conviction, be punished by a fine of not less than_____dollars nor more than_____ dollars, or by imprisonment for not less than_____days nor more than _____days; and each day's failure to comply shall constitute a separate violation.

Section VI—Conflict of Ordinances, Effect on Partial Invalidity

6.1 In any case where a provision of this ordinance is found to be in conflict with a provision of any zoning, building, fire, safety, or health ordinance or code of this (name of political subdivision) existing on the effective date of this ordinance, the provision which, in the judgment of the health officer, establishes the higher standard for the promotion and protection of the health and safety of the people shall prevail. In any case where a provision of this ordinance is found to be

in conflict with a provision of any other ordinance or code of the (name of political subdivision) existing on the effective date of this ordinance which establishes a lower standard for the promotion and protection of the health and safety of the people, the provisions of this ordinance shall be deemed to prevail, and such other ordinance or codes are hereby declared to be repealed to the extent that they may be found in conflict with this ordinance.

6.2 If any section, subsection, paragraphs, sentence, clause, or phrase of this ordinance should be declared invalid for any reason whatsoever, such decision shall not affect the remaining portions of this ordinance, which shall remain in full force and effect; and, to this end, the provisions of this ordinance are hereby declared to be severable.

Section VII—Effective Date

7.1 This ordinance shall be effective on and after the_____day of_____, 19__.

Appendix C

Engineering Information Forms

The pertinent information needed on individual sewage disposal systems prior to approval by the health or other agency having jurisdiction is outlined in Appendix B. In those instances where subdivision developments are involved, considerably more data are needed by the health agency prior to approval of water and sewage service facilities. The possibility of providing connections to existing municipal systems or the construction of community water and sewage systems should receive first consideration. In the extreme situation where this is not possible, and when subsoil conditions are favorable, information of the type called for in the following "Statement of Information" has been found satisfactory in one State. Unless real estate developments in non-sewered areas are properly planned and designed under competent sanitary engineering supervision, public health hazards and nuisances may result, with attendant economic loss to the community.

STATE DEPARTMENT OF HEALTH

Statement of Information

Regarding Water and Sewerage Service for Realty Subdivisions

To the State Commissioner Health_____19_____

Sir:

As required by the provisions of section ___ of Article _____ of the Public Health Law, the following statement is made and submitted with the plat of a proposed realty subdivision in_____.

(State)

General Information

1. Name of subdivision_____
2. Owner_____

(State name of person, company, corporation, or association owning the subdivision)

3. Business address_____
4. Officers_____

(If organized, give names of officers)

5. Location _____

(Give name of incorporated village or town in which subdivision is located)

6. Area of subdivision_____Number of lots_____

(Total size in acres)

Families accommodated_____

7. Do you intend to build houses on this subdivision?_____
   Do you intend to sell lots only?_____
   Do you intend to build on some lots and sell others without buildings?_____
8. Is this subdivision or any part thereof located in an area under the control of local planning, zoning, or other officials?_____
   If so, have these plans been submitted to such authorities?_____
   Have these plans been approved or disapproved by such governing authority?_____
9. Nature of soil_____
   (Describe to a depth of 10 feet if tile fields are to be used for sewage disposal, or 20 feet if leaching pits are proposed, giving thickness of various strata, such as top soil, clay, loam, sand, gravel, rock, etc.)
10. Topography_____
    (State whether ground is flat, rolling, steep, or gentle slope, etc.)
11. Relative elevation of water table below ground surface_____
    (Give maximum and minimum, if there is any variation)

Water Service

12. Proposed method of supplying water_____
    (Describe in detail, giving name of municipality, water district or company, if a public water supply is to be used.)
13. State approximate *distance* to nearest public water supply main of municipal system_____
    (Give name of municipality, water district, or company)

Sewerage Service

14. Proposed method of collection and disposal of sewage_____
    (Give name of municipality or sewer district, if public sewers are to be used)
15. State approximate *distance* to nearest public sewer main of municipal system_____

Storm Water Drainage

16. State proposed method, if any, of disposing of surface water from streets, roofs, land, and other areas_____

Subdivision Owners Who Intend to Build Homes Must Submit the Following Additional Information:

Additional Information:

17. Cellar drainage: Are cellar or footing drains to be installed?_____
If so, how will drainage be disposed of?_____

18. Laundry wastes: Are laundry tubs to be located in basement?_____
If so, how will wastes be disposed of?_____
It is hereby agreed that if the attached plans dated_____
or any amendment or revision thereof, are approved by the State Department of Health, installation of water supply and sewage disposal facilities will be made in accordance with the details thereof as shown on such approved plans. If the subdivided lands shown on such plans are sold before such installations are made, it is agreed that reference to said plans will be made in the deed or contract of sale, and a covenant inserted therein requiring the purchaser to install such facilities in accordance with such approved plans.

Signature_____
Official title_____
This statement must be signed by the owner of the land platted for subdivision or the responsible official of the company or corporation offering the same for sale.

Important Note

This form must be accompanied by:

(1) One U. S. G. S. topographic map or other general map showing exact location and approximate boundaries of subdivision.

(2) A print on cloth for filing with the State Department of Health, together with such other tracings and prints (see below) as may be necessary for filing with the county clerk and owner of the subdivision, showing:
   (a) subdivision layout, including streets, building lines, lot dimensions, and other pertinent data;
   (b) existing and proposed water mains, if available. If public water supply is available, show existing and proposed water mains for all lots, and submit a copy of the contract between the developer and the waterworks officials, or a letter from such officials stating that an agreement has been reached regarding the supply of such facilities.
   (c) existing and proposed sewers; if already approved by Department give date of approval; or, if not approved, application must be made and detailed plans of sewer extensions submitted by officials in charge of sewer systems, in accordance with section_____of the Public Health Law.
   (d) details of a typical lot arrangement showing general location of well and septic tank, subsurface absorption devices, etc.

(where either or both public water and sewerage service are inaccessible), plus the following:

(1) development of well (giving sufficient detail to show how the well will be developed and protected from pollution, its depth, and strata penetrated).

(2) cross section of soil showing depth of various strata (unless explained in detail under item 9).

(3) plan and section of all parts of sewage disposal system, giving all dimensions and grades.

(4) actual field results of soil tests to determine absorptive capacity of soil (may be submitted with correspondence).

Inasmuch as stamp of approval must be placed on face of plans, a space 3 by 6 inches should be reserved for this purpose. This space must be blocked out in white if blueprints are submitted.

Size of plans for filing with county clerk; 20 by 20 inches or 20 by 40 inches, tracing cloth or white prints on cloth.

Appendix D

Drainage Fixture Unit Values

Type of Fixture or Group of Fixtures	Drainage Fixture Unit Value
Automatic clothes washer (2" standpipe)	3
Bathroom group consisting of a water closet, lavatory and bathtub or shower stall:	
Flushometer valve closet	8
Tank type closet	6
Bathtub (with or without overhead shower)	2
Combination sink and tray with food disposal unit	4
Combination sink and tray with one 1½" trap	2
Combination sink and tray with separate 1½" traps	3
Dental cup or cuspidor	1
Dental lavatory	1
Drinking fountain	½
Dishwasher, domestic (gravity drain)	2
Floor drains with 2" waste	3
Kitchen sink, domestic, with one 1½" waste	2
Kitchen sink, domestic, with food waste grinder	2
Lavatory with 1¼" waste	1
Laundry tray (1 or 2 compartments)	2
Show stall, domestic	2
Showers (group) per head	2
Sinks:	
Surgeon's	3
Flushing rim (with valve)	6
Service (trap standard)	3
Service (P trap)	2
Pot, scullery, etc.	4
Urinal, pedestal, syphon jet blowout	6
Urinal, wall lip	4
Urinal stall, washout	4
Urinal trough (each 6 ft. section)	2
Wash sink (circular or multiple) each set of faucets	2
Water closet, tank operated	4
Water closet, valve operated	6
Unlisted fixture drain or trap size:	
1¼" or less	1
1½"	2
2"	3
2½"	4
3"	5
4"	6

Appendix E

Suggested Specifications for Watertight Concrete

1. *Materials*

Portland cement should be free of hard lumps caused by moisture during storage. Lumps from dry packing that are easily broken in the hand are not objectionable.[1]

Aggregates, such as sand and gravel, should be obtained from sources known to make good concrete. They should be clean and hard. Particle size of sand should range very fine to ¼ inch. Gravel or crushed stone should have particles from ¼ inch to a maximum of 1½ inches in size. Water for mixing should be clean.

2. *Proportioning*

Not more than 6 gallons of total water should be used for each bag of cement. Since sand usually holds a considerable amount of water, not more than 5 gallons of water per bag of cement should be added at the mixer when sand is of average dampness. More mixing water weakens the concrete and makes it less watertight. For average aggregates, the mix proportions shown in the table below will give watertight concrete.

Average Proportions for Watertight Concrete

Max. Size Gravel (in.)	Cement (volume)	Water [1] (volume)	Sand (volume)	Gravel (volume)
1½	1	¾	2¼	3
¾	1	¾	2½	2½

[1] Assuming sand is of average dampness.

3. *Mixing and Placing*

All materials should be mixed long enough so that the concrete has a uniform color. As concrete is deposited in the forms, it should be

[1] Type V portland cement may be used when high sulfate resistance is required.

tamped and spaded to obtain a dense wall. The entire tank should be cast in one continuous operation if possible, to prevent construction joints.

4. *Curing*

After it has set, new concrete should be kept moist for at least seven days to gain strength.

Appendix F

Industrial Waste Treatment

Septic tank systems are not employed for the treatment of industrial wastes from large manufacturing industries. In small industrial plants, septic tank systems, assisted as needed by supplementary processes may be used advantageously either for treating wastes to render them suitable for final disposal by one of the methods described in Part II, or for conditioning wastes to render them acceptable for discharge to sewer systems where they would otherwise be objectionable.

It is important to note that the design of septic tank systems for treatment and disposal of industrial wastes is not sufficiently simple to permit formulation of specific criteria for design. This is because industrial wastes vary widely in their composition; in fact, rarely do any two plants produce wastes of the same character and composition. The design of an industrial waste treatment and disposal system is, therefore, a problem requiring specialized sanitary engineering consultation, and this consultation usually includes special laboratory analyses and studies of the particular wastes under consideration. With these precautions, however, it is possible, in many instances, to develop a workable septic tank system which is actually simple, effective, economical, and within the means of the small industrial plant.

The following is intended to indicate only qualitatively some of the methods applicable to a few industrial wastes. The particular design for any given waste must be prepared by competent sanitary engineers.

LAUNDRY WASTES AND OTHER GREASY WASTES

Wastes derived from laundries and some other sources, which contain soaps, oil, and greases in relatively low concentrations, may be successfully disposed of by one of the methods previously described, provided the greasy substances are first removed. If greasy substances, including soaps and oils, are discharged into absorption systems, they accumulate and soon cause clogging of the soil pores.

The greasy substances contained in wastes are of two types: (1) the floatable greases, which are nonemulsified and which, therefore, upon quiescence or standing, will separate and rise to the surface of the liquid to form a surface layer; and (2) the emulsified greases, which do not separate upon standing. Both of these components may be present in considerable concentrations, and both must be removed.

Properly designed, conventional grease traps, such as those used for restaurant wastes, will remove floatable grease, but not emulsified grease. Emulsified grease may be removed in a practical manner, however, either (1) by passing the waste through a rock filter, or (2) by chemically flocculating the waste.

Where relatively low concentrations of emulsified grease are present, the rock filter process may be successfully used. The rock filter serves to deemulsify the grease, changing it to floatable grease so that it may be subsequently removed by simple trapping. Septic tank units may be employed advantageously both for trapping the floatable grease and to serve as the container for the rock filter. The servicing required for this system includes removal of the accumulated floatable grease at regular intervals and occasional replacement of the filter rock. The sizes of the trap and rock filter units will depend upon the quantity of the waste and its composition, as determined by laboratory analyses.

Where high concentrations of emulsified grease are present, a chemical flocculation process may be needed. For all of these processes (trapping, flocculation, and settling), septic tanks may be used as the most economical means of obtaining the necessary capacities. Also required, as accessories to the flocculation process, are a suitable electrically operated stirring device and a volumetric type chemical feeder. Maintenance of the system includes keeping the chemical feeder stocked with chemicals and periodic pumping of accumulated sludge from the settling basin. In this process, the grease particles are agglomerated by the flocculating action into large particles which settle out in the settling basin. The sizes of the various tanks, the amounts of flocculating chemicals needed, and the frequency of pumping required will depend upon the quantity of the waste and its composition, as determined by laboratory analyses.

SLAUGHTERHOUSE, DAIRY, AND OTHER ORGANIC WASTES

These wastes are generally characterized by very high concentrations of organic materials, up to (and even exceeding) 100 times the strength of ordinary sanitary sewage. Part of the organic material is in true solution, and this may sometimes be disposed of by simple underground absorption, provided there is adequate area and provided a suitable schedule for resting the absorption areas is maintained. Much of the organic material, including the emulsified greases, is in colloidal suspension. Colloidal particles will clog underground absorption systems. They do not settle out on quiescence and, therefore, have to be removed by some means, such as by flocculation and sedimentation, or by application to trickling filters followed by settling. As in the preceding example, septic tanks may advantageously be used to provide the necessary tank capacities for the trapping, flocculating, and settling processes.

MINERAL OR INORGANIC WASTES

Mineral and similar wastes present special problems generally requiring chemical neutralization or other chemical treatment before the wastes may be filtered or absorbed into the ground. Important factors are the metallic and nonmetallic ions prescnt, their concentrations, and, for underground absorption the nature and importance of the water basin lying below the area intended for absorption. Septic tanks can sometimes be used advantageously in the solution of these problems, as chemical reaction chambers, settling tanks, etc.

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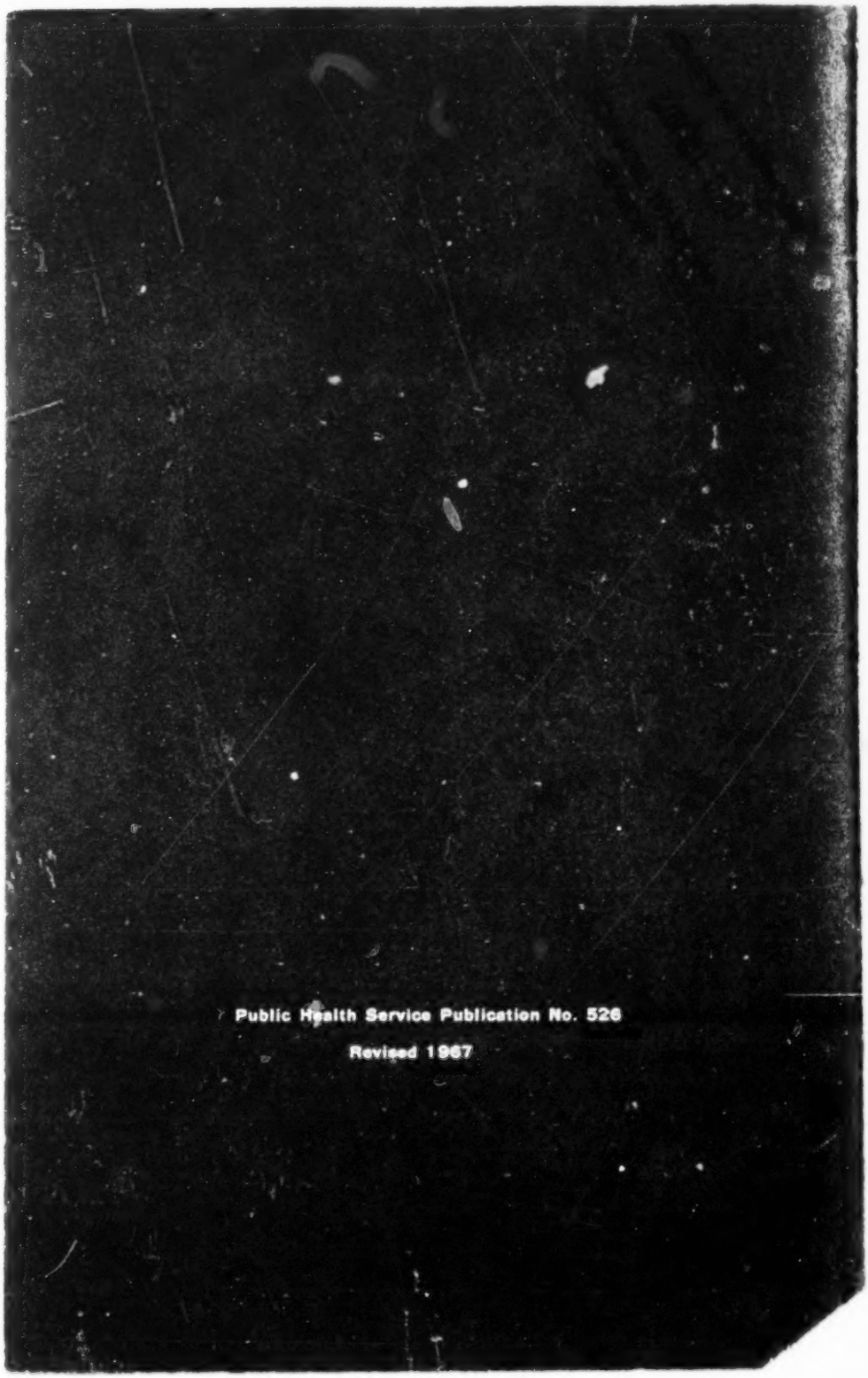

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